Walter W. Bradley

STATE OF CALIFORNIA
DEPARTMENT OF NATURAL RESOURCES
RICHARD SACHSE, Director

DIVISION OF MINES
FERRY BUILDING, SAN FRANCISCO

WALTER W. BRADLEY — State Mineralogist

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STATE DIVISION OF MINES
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CALIFORNIA

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PREFACE

The Division of Mines (formerly State Mining Bureau) is maintained for the purpose of assisting in all possible ways in the development of California's mineral resources.

As one means of offering tangible service to the mining public, the State Mineralogist for many years has issued an annual or a biennial report reviewing in detail the mines and mineral deposits of the various counties.

As a progressive step in advancing the interests of the mineral industry, and as permitting earlier distribution to the public, publication of the Annual Report of the State Mineralogist in the form of monthly chapters was begun in January, 1922, and continued until March, 1923. Owing to a lack of funds for printing this was changed to a quarterly publication, beginning in September, 1923. For the same reason, beginning with the January, 1924, issue, it became necessary to charge a subscription price. This covers approximately the cost of printing.

Pages are numbered consecutively throughout the year and an index to the complete report is included annually in the closing number.

Beginning with the 1930 issues, the activities and progress of the Geologic Branch are recorded also in these quarterly chapters. The important part that geology plays in the economic development of our mineral resources is further recognized in the change of title from *Mining in California* to CALIFORNIA JOURNAL OF MINES AND GEOLOGY, beginning with the January, 1933, chapter.

While current activities of all descriptions are covered in these chapters, the practice of issuing from time to time technical reports on special subjects will be continued as well. A list of such reports now available is appended hereto, and the names of new bulletins will be added in the future as they are completed.

The chapters are subject to revision, correction and improvement. Constructive suggestions from the mining public will be gladly received, and are invited.

The one aim of the Division of Mines is to increase its usefulness and to stimulate the intelligent development of the wonderful, latent resources of the State of California.

Types of Reports

In general the reports presented in these chapters are grouped into three classes:

1. Mines and mineral resources of a given county or area (describing kind, character, distribution and extent of development).

2. Specific economic and industrial mineral products (listing and describing the resources over the entire state of a given mineral substance, e.g., feldspar).

3. Geological reports on specific areas (recording results and conclusions with maps, derived from field studies; and tied in with economic possibilities and developments).

REPORTS OF DISTRICT MINING ENGINEERS

In 1919–1920 the Mining Bureau was organized into four main geographic divisions, with the field work delegated to a mining engineer in each district, working out from field offices that were established in Redding, Auburn, San Francisco and Los Angeles, respectively. This move brought the office into closer personal contact with operators, and it has many advantages over former methods of conducting field work, including lower traveling-expense bills for the Bureau's engineers. In 1923 the Redding and Auburn field offices were consolidated and moved to Sacramento.

The Redding office was reestablished in 1928, and the boundaries of each district adjusted. The counties now included in each of the four divisions and the location of the branch offices are shown on the accompanying outline map of the state. (Frontispiece.)

Reports of mining activities and development in each district, prepared by the District Engineer, will continue to appear under the proper field division heading.

REDDING FIELD DISTRICT

CHAS. VOLNEY AVERILL, Mining Engineer

There is no report from the Redding Field District on account of unfinished field work.

SACRAMENTO FIELD DISTRICT

C. A. LOGAN, Mining Engineer

On account of unfinished field work, there is no report from the Sacramento Field District in this issue.

SAN FRANCISCO FIELD DISTRICT

C. McK. LAIZURE, Mining Engineer

Reports covering the mines and mineral resources of all of the counties in the San Francisco Field District are now available, and field work at present is confined to investigations for special reports upon various economic minerals.

LOS ANGELES FIELD DISTRICT

CURRENT MINING ACTIVITY IN SOUTHERN CALIFORNIA

By W. B. Tucker, District Mining Engineer and
R. J. Sampson, Assistant Mining Engineer

OUTLINE OF REPORT

During the past years, 1938 and 1939, there was an increase in mining activity in southern California, especially in gold mining, with increased production in gold over previous years.

The most active mining districts during 1938 and 1939 are as follows:

Summary.

IMPERIAL COUNTY

Cargo Muchacho District, near Ogilby. The properties under production were the American Girl, operating a 175-ton flotation plant; Holmes & Nicholson Mining & Milling Co. increased the capacity of its cyanide plant to 70 tons; Sovereign Mining & Development Co. increased the capacity of its cyanide plant to 35 tons.

In the *Picacho Mining District,* Picacho Gold Mining Co. continued testing the property with drill holes, with plans to install a 500-ton cyanide plant.

Mesquite Placers were tested thoroughly by Desert Gold & Aluminum Corp. and the results of drill holes were encouraging enough to warrant the company's drilling a well which developed sufficient water for a screening and concentration plant.

Pacific Coast Manganese Co., of Los Angeles, acquired a group of manganese claims, situated in the Chocolate Mountains, in T. 11 S., R. 21 E., S. B. M., 8 miles southeast of Midway Well, and 30 miles northeast of Glamis. These claims are located on what was formerly known as the Tolbard Manganese Deposit. The company leased the Paymaster mill and tests are being conducted on the manganese ore to produce 70 per cent MnO_2 concentrate for chemical use.

INYO COUNTY

There was a renewal of mining activity in the Argus Range and in the Skidoo District. The mines under production were Arando, Mohawk, Davenport and Ruth. On the latter property, the cyanide plant was increased to treat 70 tons of ore.

The Del Norte Group of Mines was under active development, the ore being trucked to Keeler for treatment in Keeler Gold Company's mill. Skidoo Mine was worked by leasers and ore treated at the Journigan Mining & Milling Company's mill at Emigrant Springs. There was considerable activity in Coso District, a number of small properties producing.

There was only a small amount of activity in the lead-silver districts in the county during the year. The Gold Bottom and Ophir mines, north of Trona, were shippers of ore to smelters. The Long John Mine, in the Inyo range of mountains, was reopened and shipped ore to U. S. Smelting Company's smelter at Midvale, Utah.

Tungsten mining was quite active in the Bishop District. The producing properties were Bishop Tungsten Co., El Diablo Mining Co., Pine Creek Tungsten Mine, operated by United States Vanadium Corp., and Tungsten City Milling Co.

A 20-ton Nichols-Herreschoff furnace was installed on the Coso Quicksilver Mine near Coso Hot Springs and production of mercury started.

KERN COUNTY

There was increased activity in gold and silver mining in the Mojave, Tropico, Kernville and Randsburg districts.

In the *Mojave District,* the Cactus Mines, Inc., installed a 130-ton cyanide plant. Golden Queen Mining Co. increased the milling capacity of the cyanide plant to 500 tons per 24 hours. Lodestar Mining Co. continued shipments of ore to Golden Queen mill, the mine being

connected by a crosscut tunnel with Golden Queen haulage tunnel level. Eureka Mine, adjoining Queen Esther Mine, shipped ore to Golden Queen mill. The Exposed Treasure and Desert Queen shipped ore to Burton Bros, Inc. Soledad Extension Mine was operated by the Golden Queen Mining Co. Whitmore Mines were operated by leasers with shipments of ore to Golden Queen mill. Pride of Mojave Mine installed 60-ton flotation plant for treatment of the mine run of sulphide ore. At Tropico Mine, Rosamond, Burton Bros., Inc., increased the capacity of their cyanide plant to 100 tons per day.

In the *Randsburg District* the productive properties were Yellow Aster Mine, operated by the Anglo-American Mining Corp., who increased the capacity of their operations to 3000 tons per day; Big Butte, Operator, King Solomon, Big Dyke and Black Hawk.

In the *Kernville District,* Big Blue Mines operated a 150-ton flotation plant steadily during the year.

Gwynne Mine, in Green Mountain Mining District, was in operation.

LOS ANGELES COUNTY

Governor Mine, in Cedar Mountain District, was under steady production, treating 100 tons of ore per day and the adjoining Red Rover Mine was unwatered and the shaft retimbered.

Rogers-Gentry Mine, in the Neenach District, was under development by the Rascob interests, and a new shaft was sunk on the property, with considerable underground drifts driven on the vein.

MONO COUNTY

The principal activity in mining was in the Bodie, Blind Springs Hill, Masonic, Mono Lake, May Lundy and Silverado districts.

The productive mines are as follows: Roseclipp Mining Co. operated the Standard Mining Company's property on mine dumps. The 250-ton cyanide plant was operated continuously. At the Little Bodie Mine, a 25-ton flotation plant was installed during the latter part of 1938. Simpson Gold Mine, situated in the Mono Lake District, operated during 1938 and 1939. In the Blind Springs Hill District, the Comanche Mine was being rehabilitated and a 100-ton flotation plant installed on the property.

At the May Lundy Mine, a 40-ton flotation plant was installed to treat tailings from the old mill. The Silverado Mine was operated by Sierra Consolidated Mines Co. until September, 1938, when operations were suspended due to exhaustion of orebodies. This property was one of the largest silver producers in 1937. Near Benton, at the Black Rock Tungsten Mine, a 100-ton concentration plant was installed and operated continuously during 1938 and 1939.

RIVERSIDE COUNTY

The active districts in this county were in the Chuckawalla, Eagle Mountains, Pinto Basin and Pinacate. In the Chuckawalla District, the Red Cloud Mine was a producer. In the Eagle Mountains, at the Black Eagle Mine, a 100-ton concentration plant was installed; lead-copper concentrates carrying gold and silver values were shipped to smelters. In Pinto Basin, the Golden Rod and Golden Bee mines

were small producers. The Pinacate District, the Ida-Leona Mine was productive.

SAN BERNARDINO COUNTY

The principal activity was in the Atolia, Dale and Stedman districts. The principal productive mines are as follows: The Gold Crown Mine in the Dale District; the 50-ton cyanide plant was moved from the company's mine in Riverside County to the Supply Mine in San Bernardino County. Kelly and Santa Fe mines were producers in the Atolia-Randsburg District; also Atolia Tungsten Mine was a producer of tungsten. In the Stedman District, the Bagdad-Chase Mine was reopened and shipped ore to smelters in Arizona.

SAN DIEGO COUNTY

In the Julian Mining District there was some activity in the reopening of the following mines: Ranchito, Gardner, Harper Ranch and Redman, with a small production of gold.

The total amounts of the gold and silver production from the twelve southern California counties for the year, 1938 were $4,895,199 and $1,085,505, respectively. The production of Kern County amounted to $3,034,605 gold and $742,256 silver. The 1939 figures are not yet available.

NONMETALLIC MINERALS

A renewal of interest in the development and production of nonmetallic minerals was noted in 1938 and the output showed a slight increase over 1937. The 1939 data are not yet available.

BENTONITE

The production of this material was principally from Inyo and San Bernardino counties. In Inyo County, the production came from one property situated in Coso Range and from four properties in San Bernardino County, near Hector. The California Talc Co. was the largest producer.

DIATOMITE

The deposits of diatomite in Santa Barbara County, in the vicinity of Lompoc, are the largest in California and the material is of superior quality, particularly for filtration uses. Two properties were under production, the Johns-Manville Products Corp. and the Lompoc Mining Products Co., the former operating to capacity.

The deposit of The Dicalite Co., located in the San Pedro Hills near San Pedro, was a steady producer during the past two years.

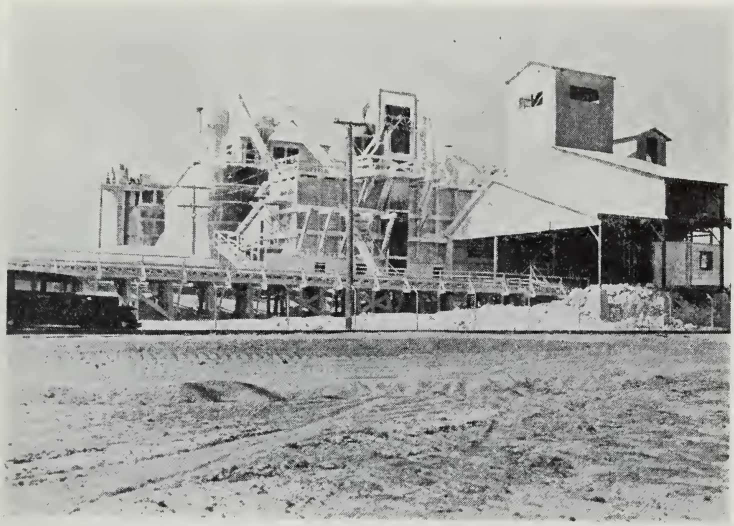
FELDSPAR

Two feldspar deposits in San Diego County were steady producers in the Campo District.

GYPSUM

Shipments of gypsum showed an increase in value and tonnage. The United States Gypsum Co. operated its property, located in the Little Santa Maria Mountains, 27 miles northwest of Blythe, River-

side County. Pacific Portland Cement Company's property, located in the Fish Mountains, 26 miles northeast of Plaster City, Imperial County, was under continuous operation during the past two years.



Pacific Portland Cement Company's Gypsum Plant, Plaster City, Imperial Co.

PUMICE AND VOLCANIC ASH

There was some increase in activity in the development and mining of pumice and volcanic ash. The principal production was from Imperial, Inyo, Kern and Mono counties.

SILICA (SAND AND QUARTZ)

There was some increase in production of silica and silica sand over previous years, the production being from Riverside and San Diego counties.

SILLIMANITE-ANDALUSITE-KYANITE GROUP

The Champion Porcelain Co. operated its andalusite deposit, located in the White Mountains, Mono County. Shipments of kyanite were made at intervals by Vitrefrax Corp., from a large deposit located in the Cargo Muchacho Range near Ogilby, Imperial County.

TALC

The principal production of talc came from Inyo and San Bernardino counties. In Inyo County, the principal shipments were from Pacific Coast Talc Company's property near Darwin; Sierra Talc Company's property near Keeler and Darwin. The Southern California Minerals Company's deposit in the Kingston Mountains was also a producer.

In San Bernardino County, the principal production was from the Western Talc Company's deposit at Acme; and the Pacific Coast Talc Company's deposit near Silver Lake.

SALINES

The main sources of the salines are the lake beds of the desert regions of Imperial, Inyo, Kern, Los Angeles and San Bernardino counties.

The principal production of borax was from Kern County, by Pacific Coast Borax Co., near Kramer, and by the American Potash &

Pacific Coast Borax Co., Kramer, San Bernardino Co.

Chemical Co., from the brines of Searles Lake, San Bernardino County. Two plants were in operation on Searles Lake, American Potash & Chemical Co. producing potash, soda and borax; and the West End Chemical Co. producing soda. Two plants were under operation on

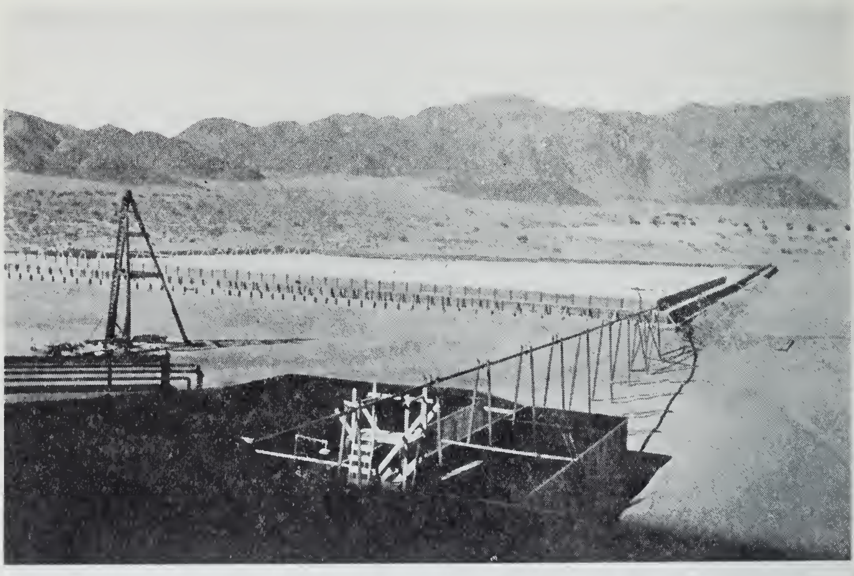


Photo by Walter W. Bradley

Outside borax storage, American Potash and Chemical Co., at Searles Lake, San Bernardino County.

Owens Lake producing soda and borax. The Pacific Alkali Co. was a steady producer. The other plant operated by the Natural Soda Products Co. was forced to suspend operations, due to the flooding of the lake by excess water from the Los Angeles aqueduct.

Photo by Walter W. Bradley

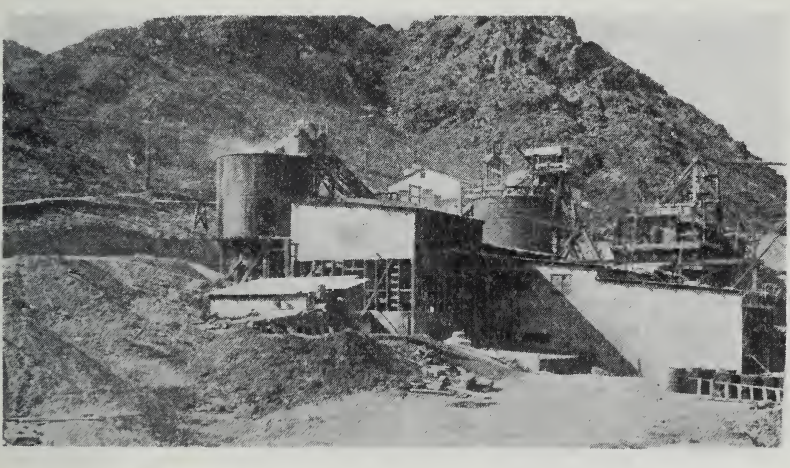
Plant of American Potash and Chemical Co., at Trona on Searles Lake, San Bernardino County.

METALS

IMPERIAL COUNTY

American Girl Mine. The property comprises 24 claims, situated in the Cargo Muchacho Mining District, in Sec. 17, T. 15 S., R. 21 E., S. B. M., 5 miles northeast of Ogilby, a station on the Southern Pacific Railroad; elevation 750 ft.; owner, *O'Brien Mines Co., Inc.*, J. J. O'Brien, president; A. T. Balmforth, secretary; W. D. McMillen, superintendent. Office address is P. O. Box 465, Ocean Beach, Calif.

Three parallel veins occur in schist, strike E. and W., dip 35° S. The veins have a thickness of 20 ft. to 50 ft. The ore in these veins is a soft, fine-grained schist, with an intermingling of quartz. The vein

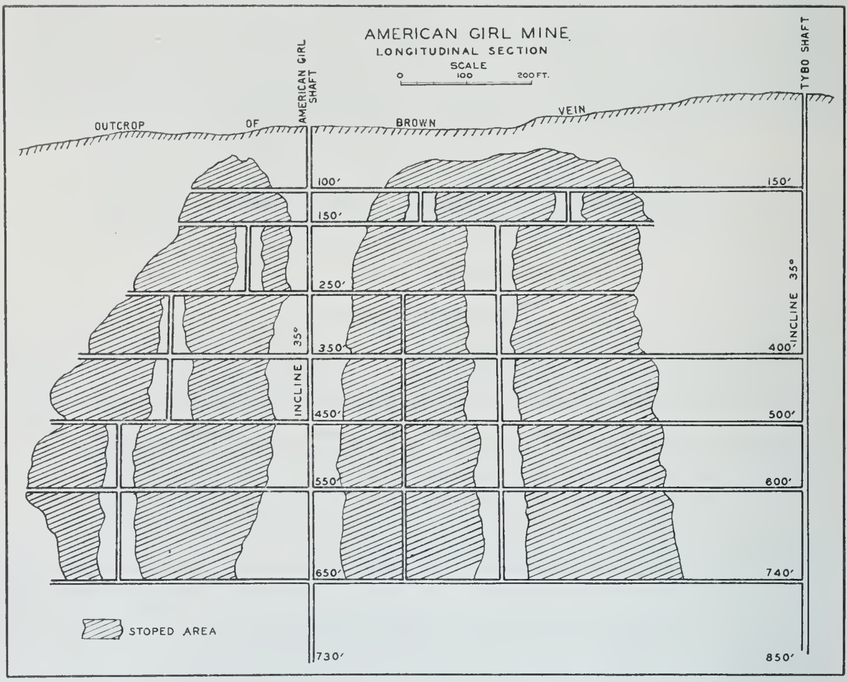


Tybo Shaft and Flotation Plant, American Girl Mine, Ogilby, California.

quartz is mineralized with pyrite and chalcopyrite. The pyrite carries the gold values. The principal development work is on what is known as the Brown Vein.

Development: The American Girl Shaft has been sunk on an inclination of 35° in the footwall of the Brown Vein to a depth of 730 ft. The main working shaft, known as Tybo Shaft, is located 750 ft. west of the American Girl Shaft and is sunk on the Brown Vein to a depth of 850 ft. on an inclination of 35°. The two shafts are connected on the 400, 500 and 600-ft. levels. The orebody is mined by square-set system of stopes.

Power plant: 3-cylinder, 350-h.p. diesel engine, direct connected with 212 K. W. generator; 430-cu. ft. Sullivan compressor, driven by



125-h.p. caterpillar gas engine. Ore is hoisted in 2-ton skip by 50-h.p. electric hoist; dumped into coarse ore bin with a capacity of 150 tons. The ore from coarse-ore bins goes to flotation plant with a capacity of 165 tons per 24 hours. Flotation concentrates are shipped to Magma Copper Company's smelter at Superior, Arizona. During 1938, 60,000 tons of ore was mined and milled.

Water for mining and milling is secured from the company's well which has a depth of 500 ft., located 2½ miles southwest of the mine. Water is pumped by Gould Triplex pump, through 2½-in. pipeline to storage tank above the mill. Eighty men are employed in mine and mill. Suspended operations in August, 1939.

Bibl.: State Mineralogist's Reports XIII, p. 331; XIV, pp. 728-729; XXII, p. 255.

Blossom Mine. It comprises 2 patented claims known as the Drifted Snow No. 4 and No. 5 owned by the *Vitrefrax Corp.*, 5050 Pacific, Vernon, Calif., and 6 claims held by location; under lease to Thomas Woodruff and L. C. Stubbins, of Los Angeles. The property is situated in the Cargo Muchacho Mining District, 4 miles east of Ogilby, a station on the Southern Pacific Railroad; elevation 400 ft.

Two parallel veins occur in gneissoid granite; strike N. 20° W., dip 50° W. Width is 12 in. to 4 ft. Developed by two shafts, the Blossom Shaft was sunk on the vein to a depth of 280 ft.; now caved. About 400 ft. south of this shaft, the Velencia Shaft, sunk on the vein to a depth of 240 ft., has been retimbered and the development work is being done from this shaft. On the 140-ft. level, a drift was driven north 20 ft. on the Blossom vein and a crosscut driven 23 ft. east which cut a vein in the footwall with an average width of 4 ft., with a drift south on the vein for a distance of 40 ft.; then a winze sunk on vein to a depth of 40 ft. The vein quartz is mineralized with free gold, associated with pyrite and chalcopyrite. Ore being extracted is reported to carry from $12 to $15 per ton in gold.

Equipment consists of 12-h.p. Western gas engine hoist and 120-cu. ft. Gardner-Denver compressor. Three men are employed.

Bibl.: State Mineralogist's Reports XII, p. 238; XIII, p. 332; XIV, p. 729; XXII, p. 255.

Coffey Mine. It comprises 6 claims situated on the west slope of the Cargo Muchacho Mountains in the Tumco Mining District, 5 miles north of Ogilby; elevation 800 ft.; owner, Edward Coffey, Ogilby, Calif.

A quartz vein occurs in gneissoid granite; strike N. 40° E.; dip 35° SE. Width of vein varies from 8 in. to 2 ft. Vein quartz is mineralized with hematite and copper oxides.

Development consists of a shaft sunk on the vein to a depth of 150 ft. Equipment consists of Ingersoll-Rand tugger hoist; 300-cu. ft. Ingersoll-Rand compressor; ore bin having a capacity of 25 tons.

Three men are employed.

Desert Gold and Aluminum Co., S. C. Hedrick, president; Alton Peterson, secretary; Paul B. Lowe, director; James A. Drennan, superintendent. This company owns 800 acres in placer claims; also has a lease on the *Copenhagen Group*, comprising 80 acres, situated in the Mesquite Mining District, in T. 11 N., R. 18 E., 9 miles northeast of Glamis, a station on the Southern Pacific Railroad; elevation 800 ft. to 900 ft.

This company during the past year has been active in prospecting its claims with Airplane placer drill. The general course of the gold-bearing gravel is northeast and southwest. The area proven is said to be two miles in length along the course of the channel and about one-half mile in width. The bedrock is schist and the gravel overlying the bedrock is from 16 ft. to 50 ft. in thickness. It is reported that the drill holes indicate the gravel carries values in gold from 30 cents to $2 per cu. yd.

Development consists of slope shaft sunk on an incline of 15° to the southwest which cuts the bedrock at a depth of 200 ft., with 800

ft. of drifts and crosscuts on the 50-ft. level. There is also a vertical shaft sunk to bedrock, the depth of which is 50 ft. The company also drilled a well 700 ft. deep with 12-in. casing, situated 5 miles southwest of Mesquite Placers. The well equipment consists of 6-in. Pomona turbine pump, driven by 80-h.p. Atlas Imperial diesel engine which also drives 20 K. V. A. generator to furnish power for screening plant. The capacity of the well is 300 gal. per minute.

At the mine there is a coarse-ore bin, with railroad-iron grizzly. Material from bin goes to 16-ft. by 40-in. trommel where it is screened to minus ½-in. into fine ore bins. From these bins, the gravel is loaded into trucks and hauled to screening and concentration plant located near the well. The capacity of concentration plant is from 20 yd. to 30 yd. per hour.

Fourteen men are employed.

Bibl.: State Mineralogist's Reports XIV, p. 731; XXII, pp. 258-259.

Golden Queen Group of Mines. This property which includes the Golden Cross and Golden Crown mines, is situated on the western slope of the Cargo Muchacho mountains, in the Tumco Mining District, in Sec. 1 and 12, T. 15 S., R. 20 E., and in Sec. 6 and 7, T. 15 S., R. 21 E., S. B. M., 4½ miles north of Ogilby; elevation 650 ft.; owners, C. S. Walker and Ben Harrison, Ogilby, Calif. The property is under option to Thomas L. Woodruff, manager, *Sovereign Mining & Development Co.,* Ogilby.

Recently a complete underground survey of the Golden Queen Mine was made; also sampling of ore exposed in stopes on the 600-ft. level, with the object of developing the property. The formation in which the Golden Queen and Golden Crown veins occur is a micaceous quartz schist, cut by pegmatite dikes. The Golden Queen vein is probably on the same bedding plane as the Golden Crown. The silicified hornblende schist carrying gold, dips 30° south and strikes N. 80° E. Width of vein is 6 ft. to 25 ft.

Development consists of incline shaft on the Golden Queen vein to a depth of 1000 ft. on slope of 30°. The Golden Crown shaft is 1100 ft. deep on an inclination of 25°. On the Golden Queen, there is a vertical shaft 300 ft. in depth connecting with crosscut from 450-ft. level. This shaft has two compartments for a depth of 200 ft., the remaining distance is one compartment. Drifts have been run on the following levels: 450, 500, 600, 700 and 800 ft. Total amount of underground workings is 5000 ft.

Three men are employed.

Bibl.: State Mineralogist's Reports XII, p. 240; XIII, p. 337; XIV, pp. 726-728; XXII, pp. 257-258.

La Colorado Mine. It comprises 12 claims situated on the north slope of the Cargo Muchacho range of mountains, in Sec. 25 and 26, T. 14 S., R. 20 E., S. B. M., 7 miles north of Ogilby; owner, J. H. Mueller, Calexico, Calif.

Two parallel veins occur in quartzose gneissoid granite and the mineralization occurs along certain bedding planes. The veins strike N. 60° W. and dip 25° SW. Widths of veins vary from 6 ft. to 35 ft.

Development consists of incline shaft 200 ft. in depth; tunnel 200 ft. in length and a vertical shaft 70 ft. deep, with 200 ft. of drifts on 65-ft. level.

Equipment consists of 6-h.p. gas engine hoist and 150-cu. ft. Ingersoll-Rand Compressor.

During the latter part of 1936, Holmes and Nicholson Mining & Milling Co. had a lease on the property and extracted 500 tons of ore reported to have averaged $9 per ton in gold. Three men are employed on development work.

Madre and Padre Mines. The property comprises two patented claims and 8 claims held by location, situated on the west slope of the Cargo Muchacho mountains, Cargo Muchacho Mining District, in Sec. 19 and 20, T. 15 S., R. 20 E., S. B. M., 4 miles east of

70-ton Cyanide Plant, Holmes-Nicholson Mining & Milling Co., Winterhaven, Imperial Co.

Ogilby; elevation 700 ft.; owners, *Holmes & Nicholson Mining & Milling Co.*; Kenneth Holmes, president and general manager; T. J. Towne, mine superintendent; Harvey Hardy, mill superintendent; offices, Yuma, Irizona.

Developed by three incline shafts known as Padre No. 1, Madre No. 1 and No. 2. Madre No. 2 shaft is sunk on the vein to a depth of 325 ft. and about 300 ft. north of this shaft, is Madre No. 1 shaft sunk on the vein to a depth of 250 ft. Padre No. 1 shaft is 500 ft. north of Madre No. 1 shaft. The underground drifts and crosscuts amount to several thousand feet.

Equipment consists of 2 Ingersoll-Rand compressors, one 320 cu. ft., the other 220 cu. ft.; and 2 gas-driven hoists. Ore mined is hauled by trucks to the company's mill near Winterhaven, a distance

of 12 miles. The cyanide plant has a capacity of 70 tons per 24 hours. Forty men are employed at mine and mill.

Bibl.: State Mineralogist's Reports XII, p. 242; XIII, p. 343; XXII, p. 259.

Paymaster Mine (silver-lead). The property comprises 12 claims, situated in Sec. 19 and 30, T. 11 S., R. 20 E. and in Sec. 24 and 25, T. 11 S., R. 19 E., S. B. M., on the eastern slope of the Chocolate Mountains, 3½ miles west of Midway Well and 25 miles by road northeast of Glamis, a station on the Southern Pacific Railroad; elevation 800 ft.; owners, L. W. Jackson and Harold Jackson, 1539 Beverly Blvd., Los Angeles. The property is under lease and bond to William Green, Morgan Lesher and associates, of Los Angeles.

The mineralization occurs along a vein that is on contact of granite gneiss and monzonite which strikes N. 45° E. and dips 70° NW.; width 8 to 15 feet. Developed by three shafts, known as Paymaster, 385 ft., President 325 ft. and Hazel, 100 ft. Recently, a new shaft has been sunk on the vein to a depth of 100 ft., between Hazel and President shafts. Development work has exposed 4 ft. of ore. The ore is lead carbonate and galena, with gold and silver values. Ore is reported to carry gold 0.03 oz., silver 11.4 oz. and lead 9.2%.

Equipment consists of hoists and compressor, with trucks. Mill consists of ball mill, concentration tables, with a capacity of 10 tons per 24 hours located at Midway Well.

Four men are employed.

Bibl.: State Mineralogist's Report XXII, pp. 262-264.

Picacho Mines. The property comprises 36 claims located in T. 13 and 14 S., R. 22 and 23 E., S. B. M., about 5 miles south of Colorado River and 20 miles north of Yuma, Arizona; elevation 580 ft.; owners, Picacho Gold Mining Co.; E. L. Jones, President, 315 W. Ninth St., Los Angeles; Hugh Park, general manager, Yuma, Ariz.; under option to the *Nipissing Mining Co., Ltd.,* Quebec, Canada.

Three parallel lenses of ore occur in schist and these ore-bodies are known as Oro Grande, Picacho and Pennsylvania. General strike of the lenses is N. 45° W., with dip of 45° SW. For the past three years the property of the company has been tested with drill holes to determine the extent of the mineralization and grade of ore to determine the size of mill to be installed.

Equipment consists of vacuum drills developed by the company and portable compressor. Thirty men are employed.

Bibl.: State Mineralogist's Reports XII, pp. 237-243; XIII, pp. 331-346; XIV, pp. 729-730; XXII, pp. 260-261.

Sovereign Group of Mines. It comprises 12 claims situated in the Cargo Muchacho mountains, in Sec. 1 and 12, T. 15 S., R. 20 E. and in Sec. 6 and 7, T. 15 S., R. 21 E., S. B. M., in Tumco Mining District, 4½ miles northeast of Ogilby, a station on the Southern Pacific Railroad; elevation 700 ft.; owner, Ben Harrison, Ogilby, Calif. The property is under lease and bond to Sovereign Mining & Development Co.; Courtney Baylor, president; Thomas L. Woodruff, general manager; W. M. Ballanger, superintendent; offices, 30 Bay State Road, Boston, Mass.

The vein occurs along a bedding plane in quartzose schist; strike N. 40° E., dip 25° SE. Widths vary from 4 ft. to 8 ft. Development consists of incline shaft 450 ft. in depth, with four levels and several thousand feet of underground workings. Ore mined is hauled by truck to the company's cyanide plant, a distance of 3 miles. The capacity of the mill is 30 tons per 24 hours.

35-ton Cyanide Plant, Sovereign Development Co., Ogilby, Imperial Co.

There was recently installed a 75-h.p., 2-cylinder Fairbanks-Morse diesel engine, direct connected with generator. They plan to increase the capacity of the mill to 60 tons per 24 hours. Twenty men are employed.

Telluride Mine (Golden Queen). The property comprises 7 claims situated on the west slope of the Cargo Muchacho Mountains, in the Tumco Mining District, 7 miles north of Ogilby; elevation 800 ft.; owner, Telluride Gold Mining Co.; A. J. Griffin, president; Roscoe Rupp, secretary; R. N. Griffin, general Manager, P. O. Box 21, Yuma, Ariz.

Quartz vein occurs in gneissoid granite; strike NE. and SW., dip 15° NW.; width 2 to 4 feet. Development consists of two shafts, one vertical shaft 50 ft. deep and incline shaft 136 ft. deep. On 136-ft. level, a crosscut is being driven north to intersect vein developed in vertical shaft.

Equipment consists of 6-h.p. gas-driven hoist and Gardner-Denver compressor, driven by 15-h.p. Fairbanks-Morse compressor. Four men are employed.

Black Hill Manganese Deposit. It comprises 8 claims situated in Sec. 18 and 19, T. 11 S., R. 21 E., S. B. M., in the Paymaster Mining District in the Chocolate Mountains, 7 miles south of Midway Well and 30 miles east of Glamis, a station on the Southern Pacific Railroad; owners, R. R. Reno, E. S. Gillette, E. J. Moreno, Yuma,

Ariz. The property is under lease to *Pacific Coast Manganese Corp.;* V. D. Whedon, president; Clyde Hawes, vice president and manager, 214 Bank of America Bldg., Beverly Hills, Calif.

Ore mined is concentrated in the Paymaster mill which has a capacity of 10 tons. They are producing a product reported to carry 70 per cent MnO_2. Six men are employed.

Bibl.: State Mineralogist's Report XXII, p. 266; U. S. Geol. Surv. Bull. 710-E.

INYO COUNTY

Arondo Mine. The property comprises 26 claims, situated in T. 23 S., R. 43 E., in the Sherman Mining District, on the eastern slope of the Argus Range, 14 miles north of Trona; elevation 4000 ft.; owners, Alice H. McIntosh, Trona, Calif., and Judge Russ Avery, Los Angeles; under lease and bond to *Argus Mining Co.*, H. P. Smith, president; Alvin B. Carpenter, consulting engineer; J. N. Gray, superintendent; offices, 650 South Grand Ave., Los Angeles.

The vein is a porphyry intrusion which occurs along a fault fissure in granite. The strike is east and west, with a dip of 54° S.; width 6 ft. to 40 ft. It is developed by two shafts. The main working shaft is known as west shaft and is sunk on the vein to a depth of 400 ft., with levels at 100, 200, 300 and 400 ft.

Equipment consists of gas-driven hoist and 100-cu. ft. compressor. Mill consists of a cyanide plant with a capacity of 60 tons per 24 hours. Fifteen men are employed.

Bibl.: State Mineralogist's Report XXXIV, pp. 381-382.

Ashford Mine (GoldenTreasure). It comprises 26 claims, situated on the western slope of the Funeral Range, 30 miles by road west of Shoshone; elevation 2000 ft.; owners, Henry J. and Louis R. Ashford, Shoshone, Calif.; under option to Bernard Granville and associates, Los Angeles.

Four quartz veins occur in gneissoid granite; strike N. 15° E., dip 65° E.; widths 6 in. to 4 ft. Development consists of shafts and tunnels. The main working shaft has a depth of 320 ft.

In the past two years $18,000 worth of ore has been shipped. Shipments have averaged about $70 per ton. Ten men are employed. Installing aerial tram 1½ miles in length.

Bibl.: State Mineralogist's Reports XV, pp. 78-79; XXII, p. 469; XXXIV, p. 383.

Bedell Placer Mines. The property is situated in Marble Canyon, 23 miles southeast of Big Pine; elevation 6000 ft.; owners, David T. Bedell and Stuart Bedell, Big Pine, Calif.

Development consists of two incline shafts sunk to bedrock to depths of 100 ft., with 500 ft. of drifts on channel. Nuggets up to $300 have been recovered. Two men are employed.

Bibl.: State Mineralogist's Report XXXIV, pp. 408-409.

Black Eagle Mine. It comprises 3 claims, situated on the west flank of the Inyo Range; elevation 8000 ft.; owners, A. T. Smith, San Clemente, Calif., and George Lewis, San Diego, Calif.; under lease

to *First National Mines Co.*, Homer Johnstone, president and manager, 801 Bartlett Bldg., Los Angeles.

The Black Eagle vein occurs on contact of granite and limestone; strike N. 70° E., dip 75° S.; width 2 ft. to 3 ft. A 25-ton amalgamation and flotation plant has been installed. Eight men are employed.

Bibl.: State Mineralogist's Reports XV, p. 75; XVII, p. 279; XXII, p. 466, XXXIV, pp. 384, 385.

Brown Monster-Reward Mines. The property comprises 8 claims situated in Russ Mining District, on the west slope of the Inyo Range, 10 miles north of Lone Pine; elevation 4000 to 5000 ft.; owners, Guy Eddie and Chas. De Corse, of Los Angeles; under lease to T. L. Brite, Lone Pine, Calif.

The Brown Monster vein strikes N. 70° W., dip 25° NE. The width varies from 4 to 12 ft. Twelve men are employed in selective mining on the Brown Monster vein, shipping 10 tons per day to mill of Burton Bros., at Tropico. The ore shipped is reported to average $40 per ton in gold.

Equipment consists of 300-cu. ft. portable air compressor; 1500-ft. aerial tram line.

Bibl.: State Mineralogist's Reports VIII, p. 263; XII, p. 136; XIII, p. 189; XV, p. 83; XXII, p. 473; XXXIV, pp. 386-388.

Del Norte Group of Mines. This property comprises 6 claims situated in the Wildrose Mining District, in the Panamint Range, 18 miles north of Wildrose Springs and 45 miles north of Trona; elevation 5300 ft.; owners, *Panamint Mining & Milling Co.*, Adolph Ramish, president; Roy C. Troeger, secretary, 972 Fourth Ave., Los Angeles; under lease to John Rogers and Morris Albertoli, Mojave, Calif.

A massive bed of quartzite 25 ft to 30 ft. thick overlies quartz monzonite; general strike east and west, with a dip of 15° N. Development consists of a number of shafts sunk through quartzite to quartz monzonite to depths of 25 ft. Ore extracted from shafts is hauled by truck to mill of the Keeler Gold Mine for testing purposes to determine the average grade of the ore that can be mined. Keeler Gold mill is also under lease. Twelve men are employed.

Bibl.: State Mineralogist's Report XXXIV, pp. 294-295.

Gold King Mine. It comprises 4 claims, situated in the Wildrose Mining District, one mile east of Journagan's mill, 16 miles northeast of Wildrose and 56 miles north of Trona, on the west slope of the Panamint Range; owner, Walter Hoover, Lone Pine, Calif.; under lease to O. A. Mittendorf, Randsburg, Calif.

A vein of quartz 6 ft. to 8 ft. wide occurs in quartz monzonite; strike east and west, dip S. 15°; developed by two incline shafts to a depth of 60 ft., with 250 ft. of drifts. Shipped 1000 tons of ore to Golden Queen mill at Mojave, reported to average $26 per ton in gold. Eight men are employed.

Hallelujah No. 3 Placer Mine. It is situated in Marble Canyon, 23 miles southeast of Big Pine; elevation 5900 ft.; owners, Dr. Vaughn, San Pedro, Calif., and Harry Mornway, Big Pine, Calif.

Development consists of incline shaft 103 ft. to bedrock, with 500 ft. of drifts on channel. Nuggets up to $26 have been recovered. Two men are employed.

Bibl.: State Mineralogist's Report XXXIV, pp. 409-410.

Inyo Gold Mine. It comprises 17 patented claims, situated in Echo Canyon, on the west slope of Funeral Range, 12 miles east of Furnace Creek Ranch; elevation 3900 ft. to 4400 ft.; owner, Mrs. E. B. Gilbert, Long Beach, Calif.; under lease and bond to Inyo Consolidated Mines, Inc., F. M. Galleher, president; Stanley Hollister, secretary, Santa Barbara, Calif.

Six parallel quartz veins occur in quartzite; strike NE. and SW., dip 35 to 55° NW. Widths vary from one to 15 ft. Development consists of inclined shaft 220 ft. in depth which connects with crosscut tunnel 695 ft. in length.

A 25-ton amalgamation and concentration plant is installed on the property. Operations were suspended the latter part of 1938.

Bibl.: State Mineralogist's Report XXXIV, pp. 399-401.

Lewis Group of Placer Mines. The property is situated in Marble Canyon, 22 miles southeast of Big Pine; elevation 6000 ft. Owner, J. C. Lewis, Big Pine, Calif.

Development consists of two shafts, each 115 ft. in depth to bedrock. Nuggets recovered vary from $5 to $26 in value. Three men are employed.

Bibl.: State Mineralogist's Report XXXIV, pp. 410-411.

Mohawk Mine. The property comprises 12 claims, situated in Argus Mining District, 7 miles northwest of Trona; elevation 2500 ft.; under lease to J. E. Netherton, Trona, Calif.

The vein which is from 3 to 14 ft. in width, occurs in granite; strikes east and west; dip 70° S. Developed by a shaft 168 ft. in depth, with levels at 50, 100 and 160 ft., with several thousand feet of crosscuts and drifts. Cyanide plant has a capacity of 30 tons. Twelve men are employed.

Bibl.: State Mineralogist's Report XXXIV, pp. 411-412.

New Discovery & Gem Mines. The property comprises 5 claims situated in Jail Canyon, on the west slope of Panamint Range, 14 miles north of Ballarat; owner, *Gem Mines, Inc.,* E. S. St. Clair, Bakersfield, Calif.

Two parallel veins occur in gneissoid granite near contact of schist. Widths vary from 2 ft. to 12 ft. Development consists of tunnel 260 ft. in length and vertical shaft 220 ft. deep. Levels have been driven at 75, 125 and 200 ft. horizons.

Mine equipment consists of hoist and compressor. Mill equipment consists of 25-ton flotation plant. Five men are employed.

Bibl.: State Mineralogist's Reports XXVIII, pp. 364-366; XXXIV, p. 413.

Poleta Mine. It comprises 4 claims situated in Poleta Canyon on the west slope of the White Mountains, 8 miles east of Bishop, elevation

5500 ft.; owners C. H. Olds and A. E. Beauregard; under lease to H. A. Van Loon, Bishop, Calif.

The vein of quartz occurs in limestone, having an E.-W. strike; dip 35° N.; width 2 ft. Development consists of tunnel 400 ft. in length. At about 200 ft. from the portal of tunnel, a shaft is sunk on the vein to a depth of 600 ft.

Mill consists of 15-ton flotation plant. Five men are employed.

Bibl.: State Mineralogist's Reports XII, p. 139; XIII, p. 183; XXXIV, pp. 414-415.

Radcliff Mine. The property comprises 10 patented claims, situated on the south side of Pleasant Canyon, on the west slope of the Panamint Mountains, about 6 miles east of Ballarat; elevation 7000 ft.; owner, W. D. Clair, Trona, Calif. Operating cyanide plant on tailings. Four men are employed.

Bibl.: State Mineralogist's Reports XXII, p. 472; XXVIII, pp. 373-376; XXXIV, p. 415.

Ruth Mine. The property comprises 13 claims, situated in the Argus Range, in South Park Mining District, 12 miles north of Trona; elevation 4000 ft.; owners, *Burton Bros., Inc.*, Tropico, Calif., George Wyman and N. E. Sweetzer, Mojave, Calif.

The orebody occurs along a fault fissure in quartz monzonite; strike N. 75° E., dip 70° S.; width 6 ft. to 40 ft. Development consists of tunnel driven N. 75° E. 800 ft. At 700 ft. from the portal of tunnel, a 2-compartment winze has been sunk to a depth of 100 ft. Ore-shoot developed on tunnel level and 100-ft. level is 200 ft. in length; average width 10 ft. Estimated tonnage of ore developed is reported to be 50,000 tons.

Mine equipment consists of 75-h.p., 2-cylinder Fairbanks-Morse diesel engine; 310-cu. ft. Ingersoll-Rand compressor; 15-h.p. single drum air hoist. Cyanide plant has a capacity of 70 tons per 24 hours. Fifteen men are employed.

Bibl.: State Mineralogist's Report XXXIV, pp. 416-418.

Wahoo Mine. It comprises 2 claims situated in the Argus Range, 6 miles north of Darwin; owner Walter Hoover, Lone Pine, Calif.; under lease to Paul Braun, Darwin, Calif.

The vein strikes N. 45° W.; dip 40° W.; width 4 ft. Three veins occur in quartz monzonite. Development work consists of a shaft sunk to a depth of 90 ft. on the vein. On the 90-ft. level, there is a drift south on the vein 150 ft. Ore is shipped to Burton Bros., Inc. Equipment consists of 6-h.p. hoist. Four men are employed.

Bibl.: State Mineralogist's Report XXXIV, p. 424.

LEAD-SILVER MINES

Big Silver Mine. It comprises 10 claims situated on the eastern slope of the Inyo Range, in the Ubehebe Mining District, on the western edge of Saline Valley, 50 miles by road north of Keeler; elevation 1600 to 3000 ft.; owner, Big Silver Mining Co., Paul Bolton, Trustee, Los Angeles. The property is under lease to Saline Valley Mining

Co., Paul Bolton, president and manager; A. B. Canfield, secretary, 247 South Ardmore Ave., Los Angeles.

Two systems of veins occur in limestone. One strikes N.-S., the other E.-W. Width of veins ranges from one to 10 ft. Development consists of a number of tunnels driven on the different veins at various elevations. Six men are employed on development work.

Bibl.: State Mineralogist's Report XXII, pp. 477-478.

Gold Bottom Mines (Copper Queen & Slate Range). The property comprises the following claims: Copper Queen, Copper Queen No. 2, Copper Queen Annex, Mountain Beauty, Sylvia and Silver Queen, totaling 100 acres, situated on the southwest slope of the Slate Range, 9 miles northeast of Trona; elevation 2230 ft.; owner, T. A. Wells, Bakersfield, Calif.; under lease and bond to Gold Bottom Mines, Inc., Emil Bender, president; F. W. Handle, secretary; T. J. Nicely, general manager, Bakersfield, Calif.

Two parallel fissures occur in limestone, strike E.-W., dip 70° S. Widths vary from 6 ft. to 8 ft. The ore is cerrusite, galena associated with pyrite and chalcopyrite, with values in gold and silver. Lower tunnel is driven east 1700 ft. on fissure. Mill adit tunnel is 1000 ft. on fissure at a higher elevation. Fissures are cut by a fault which strikes N.-S. displacing ore-bearing fissures 265 ft. to the south.

Ore shipped to the smelter at Midvale, Utah, assayed 0.63 oz. in gold, 14.5 oz. in silver, 15.9% in lead and 0.6% in copper. Mill concentrates shipped assayed 0.91 oz. in gold, 21.5 oz. in silver, 20.3% in lead and .75% in copper. Total production of property is reported to be $800,000. Gold Bottom Mines, Inc., produced $25,000 in 1936 and 1937. The production in 1937 was $15,000. A 25-ton flotation plant is located on the east side of Searles Lake, about 2 miles west of the mine. Six men are employed.

Bibl.: State Mineralogist's Report XXII, p. 501.

Long John Mine. It comprises 7 patented claims, situated on the ridge of Long John Canyon, on the west slope of the Inyo Range; elevation 5900 ft.; owner, James Walker, Glendale, Calif.; under lease to H. E. Woodson, Lone Pine, Calif. Shipping lead-silver ore to smelter at Midvale, Utah. Six men are employed.

QUICKSILVER

Coso Quicksilver Deposit. It comprises 100 acres situated in Sec. 7, 8 and 16, T. 22 S., R. 38 E., M. D. M., in the Coso Range, 2½ miles southwest of Coso Hot Springs and 11 miles east of Coso Junction, a siding on the Southern Pacific Railroad, elevation 3635 to 4300 ft.; owner, F. J. Saunders, Santa Barbara, Calif., and A. W. Leege, Santa Barbara, Calif., L. C. Dunmorin, superintendent.

The principal mineralization is confined to the rhyolite which overlies granitic rocks in Devil's Kitchen Canyon and on a hill south of the canyon. The mineralized area in the Devil's Kitchen Canyon is 1200 ft. in length, about 600 ft. in width and about 300 ft. thick. Samples taken from this orebody are reported to range from 0.16% Hg to 6% Hg. The second area of enrichment is located one-half mile northeast of Devil's Kitchen and embraces 40 acres known as the

Nicol property. The major portion of the development work has been confined to this property.

The development consists of 4 trenches about 8 ft. deep, 6 ft. wide and from 200 ft. to 400 ft. in length, run in north and south direction, and open-cuts. Ore is mined by power shovels, loaded into trucks and delivered to Herreschoff furnace, with a capacity of 20 tons per 24 hours. Ten men are employed.

Bibl.: State Mineralogist's Report XXVI, pp. 59-63.

TUNGSTEN

Bishop Tungsten Mine. The property comprises 25 acres of patented land and 4 mining claims located in the low, granite foothills, 4 miles south of Bishop, on the west side of Owens Valley; elevation 4500 ft.; owner, Joseph Rossi; under lease and option to A. T. Wilkerson and Rolph H. Moore, Bishop, Calif.

Scheelite occurs in limestone along its contact with granitic rock. The strike is NE.SW. Mineral-bearing zone is 20 ft. in width. Developed by tunnels and open-cuts. The concentration plant has a capacity of 30 tons per 24 hours. Concentrates produced carry 70 per cent to 72 per cent WO_3. Seven men are employed.

Bibl.: State Mineralogist's Report XXXIV, pp. 462-463.

El Diablo Mining Co., H. O. Johanson, secretary and manager. This company has a lease on 8 claims at Tungsten City, from the *Tungsten City Milling Co.* The property is 8 miles west of Bishop in the Tungsten Hills; elevation 5500 ft.; owner, J. V. Baldwin Estate, Los Angeles.

The orebody occurs in limestone at its contact with enclosing quartz diorite. This limestone trends north-south and stands practically vertical. The ore is scheelite, occurring in a gangue consisting of garnet and epidote. The ore occurs in lenticular masses from 50 ft. to 80 ft. long and 10 ft. to 20 ft. wide.

Development consists of cross-cut tunnel driven west 700 ft., with 200 ft. of drifts in the ore-bearing zone. Raises from tunnel level connect with large glory hole 200 ft. long and 200 ft. in width. The ore mined is hauled to the 40-ton concentration plant located near Bishop Creek road, about 3 miles west of Bishop. Concentrate produced is reported to average 70 per cent WO_3. Six men are employed.

Bibl.: State Mineralogist's Reports XV, pp. 129-130; XVII, p. 303; XXII, p. 512.

Pine Creek Tungsten Mine. The property is situated on Morgan Creek, on the eastern slope of the Sierra Nevada, about 20 miles west of Bishop; elevation 10,500 ft. to 11,000 ft.; owner, *United States Vanadium Co.,* R. J. Hoffman, president, 30 East 42d St., New York City; M. M. Shaw, superintendent, Bishop, Calif.

The deposit is a product of contact metamorphism. It occurs between a dolomite footwall and a granitic hanging wall. Its strike is N.-S. The width varies from 15 ft. to 50 ft. The mineralization consists of scheelite, molybdenite and chalcopyrite, in a garnetiferous gangue. The higher grade scheelite ores occur near footwall while molybdenite values are greater near the hanging wall. The ore is

reported to carry 1.5 per cent WO_3, 1 per cent MoS_2 and 1 per cent Cu. Two orebodies have been developed, the combined length being 1000 ft.

Development consists of crosscut tunnel 2500 ft. in length. At 1700 ft., a raise connects with upper tunnel and glory hole. Ore mined is trammed to concentration plant having a capacity of 300 tons per 24 hours. Sixty men are employed.

Bibl.: State Mineralogist's Reports XVII, pp. 301-302; XXII, pp. 511-512; XXXIV, pp. 465-466.

Tungsten City Milling Company, Raymond Stolle, P. O. Box 641, Bishop, Calif., has a lease on the Tungsten City property from J. V. Baldwin Estate, Los Angeles. Mill has a capacity of 120 tons per day and is treating tailings from old Tungsten City mill. Eight men are employed.

Bibl.: State Mineralogist's Report XXXIV, p. 467.

KERN COUNTY

Big Blue Mine. It comprises Big Blue, Beauregard, Lady Bell and Sumner group of mines, totaling approximately 210 acres, situated in the Cove Mining District, one-half mile north of Kernville; elevation 2900 ft.; owner, *Kern Development Co.*, C. S. Long, president, Hayward, Calif.; under lease and bond to Big Blue Mines, Inc., Roland Toggnazzini, president; Walter Bates, secretary, Eirind Knutsen, general manager, 605 Market St., San Francisco; John W. Prout, consulting engineer, 548 S. Spring St., Los Angeles.

Big Blue-Sumner vein occurs on contact of schist and granite; strike N. 20° W., dip 70° W.; width 80 ft. to 125 ft. Present mining operations are confined to 360-ft. and 400-ft. levels, with 5000 feet of drifts and cross-cuts.

Ore mined is hoisted through air shaft which is located southwest of Sumner shaft. Ore is hoisted in 2-ton skips to coarse ore bin, capacity of 100 tons; from coarse ore bin to Blake type of crusher, then it is conveyed by belt conveyor to fine ore bin with a capacity of 200 tons. The ore is hauled by trucks to mill on the Kern River where it is dumped onto railroad iron grizzly; then oversize to No. 8 gyratory crusher, elevated to fine-ore bin; from fine-ore bin to 18-in. belt conveyor to 6-ft. by 7-ft. Traylor ball mill in closed circuit 6-ft. Dorr classifier. Ore is ground to minus 50-mesh. Between ball mill and classifier there is a Pan-American jig where concentrate is cut, said to carry 50 oz. in gold. This concentrate goes to amalgamation barrel; overflow from classifier to 12 Krout flotation cells; finished concentrates to Oliver filter, tailings to tailings' pond. Flotation concentrates are reported to have an average value of 5 oz. in gold. The plant has a capacity of 150 tons per day; yearly capacity of 3000 tons. Total horse power to operate mill is 250. Power is secured from Southern California Edison Co. Ingersoll-Rand compressor, driven by water power, has a capacity of 1250 cu. ft. Thirty-five men are employed.

Bibl.: State Mineralogist's Reports VIII, p. 313; XIV, pp. 488-489; XX, p. 40; XXV, pp 27-28; XXIX, pp. 289-291.

Big Butte Mine. The property comprises 20 acres in Sec. 36, T. 29 S., R. 40 E., M. D. M. It is in the east end of the town of Randsburg; elevation 3550 ft.; owner, *Butte Lode Mining Co.*, 650 South Grand Ave., Los Angeles; William Wegmann, superintendent.

Two parallel veins occur in schist; strike N. 70° W., dip 45° NE.; width 1 ft. to 5 ft. The ore occurs in the quartz veins as lenses and as a mineralized schist, largely along the foot-wall of a diabase dike. The mine is developed by an incline shaft sunk on the vein to a depth of 523 ft., with 6500 ft. of cross-cuts and drifts.

Equipment consists of hoist and compressor. A 10-stamp mill is operated on ore from the mine and also on custom ore from the district. Six men are employed.

Bibl.: State Mineralogist's Report XXIX, p. 291; S. M. B. Bull. 95, p. 132.

Big Dike Mine. It comprises 5 claims located on the east slope of the Rand Mountains, one mile south of Randsburg; owners, Miller Bros., Santa Monica, Calif.; under lease to George Benko and J. D. Shea, of Randsburg, Calif.

The vein strikes N.-S.; dip 40° E. It occurs on contact of the quartz monzonite and the Rand schist; width 12 in. to 4 ft. Development consists of an incline shaft 300 ft. deep, with levels at 100, 200 and 300 ft. Mine equipment consists of hoist, compressor and air drills. Four to six men are employed.

Bibl.: State Mineralogist's Report XXIX, p. 292.

Black Hawk Mine. It comprises 130 acres situated in the Rand Mining District, 3 miles southwest of Randsburg; owner, George H. Clapp, Pittsburgh, Pa.; under lease to G. W. De La Mar and associates, Randsburg, Calif.; E. L. Haff, consulting engineer, 722 Pacific National Bldg., Los Angeles.

Three parallel veins occur in schist, with a general north strike and dip 50° to the east. Width of veins vary from 18 in. to 3 ft. Black Hawk shaft is 600 ft. in depth with 8 levels and 5000 ft. of drifts and crosscuts.

Mill equipment consists of 5 stamps, weight 1000 lb. They are treating 300 tons per month. Seven men are employed.

Bibl.: State Mineralogist's Reports XIX, pp. 166-167; XIV, p. 489; XXV, p. 29; XXIX, pp. 292-293.

Cactus Queen & Blue Eagle Mines comprise about 500 acres situated in the S.½ of Sec. 17, T. 10 N., R. 13 W., S. B. M., on the southwest slope of the Middle Buttes, 7 miles southwest of Mojave and 12 miles northwest of Rosamond; elevation 3000 ft.; owner, *Cactus Mines, Inc.*, Harvey Mudd, president; Roy W. Moore, manager; George I. Barnett, superintendent; offices, 523 West Sixth St., Los Angeles.

The country rock is dacite. The vein occurs as a fissure which may be the contact of two different flows. It strikes N. 45° E.; dips 35° E. Width of vein varies from 7 ft. to 25 ft. The vein material is quartz, mineralized with silver minerals, such as cerargyrite and argentite. The gold occurs associated with pyrite, arsenopyrite and marcasite. Development consists of an incline shaft 700 ft. in depth, with about 6000 ft. of drifts and cross-cuts.

Mine equipment consists of 95-h.p. electric-driven, single drum hoist; Ingersoll-Rand Imperial type compressor; completely equipped blacksmith shop; timber framing shop equipment.

Mine run of ore hoisted in 2-ton skips to 2 circular steel ore bins, capacity 250 tons; ore from coarse-ore bins by ore feeder to Traylor No. 8 gyratory crusher, crushed to pass 2-in. ring; then conveyed by 30-in. belt conveyor to Hummer vibrating screen; minus $\frac{1}{2}$-in. size to circular steel type of fine-ore bin, capacity 200 tons; oversize from Hummer screen returned to gyratory crusher; ore from fine-ore bin to Hardindge constant weight feeder to 5 by 7-ft. Marcy ball mill, in closed circuit, with double rake duplex Dorr classifier. Ore ground so 85% passes through 200-mesh. Ball mill and classifier are driven by 150-h.p. Westinghouse motor; overflow from Dorr Classifier to 5 by 6-ft. conditioner tank, then to 4-cell Fagergren flotation machines; concentrates containing free gold and silver sulphides to Emsco filter, then concentrates to drying room; tailings from flotation cells to cyanide plant which consists of 35 by 10-ft. Dorr primary thickener and 37 by 10-ft. Dorr 4-compartment tray washing thickener and Merrill-Crowe precipitation process. Mill has a capacity of 130 tons per 24 hours. Electric power is from the Southern Sierras Power Co. Eighty men are employed.

Bibl.: State Mineralogist's Report XXXI, pp. 471-472.

Eureka Mine. It comprises one claim of 20 acres adjoining the Queen Esther Mine, in Sec. 6, T. 10 N., R. 12 W., on the east slope of Soledad Mountain, 6 miles south of Mojave; elevation 3600 ft.; owners, Mrs. Rayburn, Los Angeles, and Mrs. Garrison, Mojave, Calif.; under lease to Morris Albertoli, Mojave, Calif.

The vein occurs in rhyolite porphyry, strikes N. 40° W., and dips 60° NE. The width varies from 5 to 10 ft. It is developed by tunnels at different elevations. Lower tunnel is 200 ft. and is driven southeast on the vein.

The production to date is over $100,000. Ore mined is shipped to the Golden Queen mill at the rate of 150 to 200 tons per week. The property is equipped with compressors, air drills, ore bins and cars. Eight men are employed.

Four Jacks Mine. It comprises 2 claims situated on the north slope of Soledad Mountain in the Mojave Mining District, 4 miles southwest of Mojave; elevation 3700 ft.; owner, Goodwin J. Knight, Los Angeles; under lease to George D. Smith, Mojave, Calif.

A quartz vein in rhyolite, strike E.-W., dip 55 to 60° S., varies in width from a few inches to about 6 ft. The quartz carries free gold, some sulphides and by weight, fifteen times as much silver as gold. Shipments by leasers have averaged about $12 to $14 per ton.

Development consists of shaft sunk on the vein to a depth of 300 ft., with three levels. Three hundred tons of ore are being shipped per month. Equipment consists of compressor, gasoline-driven hoist and air drills. Fifteen men are employed.

Golden Queen Mine. The property comprises 460 acres situated in Sec. 6 and 7, T. 12 N., R. 12 W., S. B. M., in the Mojave Mining District, on the northwest slope of Soledad Mountain, 4 miles south

of Mojave; elevation 3100 to 3800 ft.; owner, Golden Queen Mining Co., Wm. C. Browning, general manager; Chas. A. Kumke, superintendent; V. T. Berner, mill superintendent; address, Pacific Mutual Bldg., Los Angeles.

Since the description of the property published in the XXXI Report of the State Mineralogist, pp. 475-479, the capacity of the mill has been increased to 500 tons per day, of which about 200 tons is custom ore from other mines in the district. The mill is equipped for crushing, fine grinding and cyanidation, with 3-stage countercurrent decantation and precipitation by Merrill-Crowe process. Mine run of ore from 1000-ton coarse-ore bin goes to Traylor Tz. gyratory, equipped with special bowl head to permit sizes up to 12 in. Secondary crusher is Traylor gyratory, with a maximum feed of 7 in. Product

Photo by W. W. Bradley

Golden Queen Mining Company's Crushing and Cyanide Plant, Mojave Mining District, Kern Co.

from secondary crusher goes to 3-ft. Symonds crusher; then to 3 Marcy No. 67 ball mills, in series with 2 Dorr type D SF (6-ft. by 21 by 8-in.) classifiers, and one Dorr turret type DSF.B. 8-in. by 30 ft. by 12-ft. bowl classifier. Ore is ground so that 85% passes 200 mesh, after which it is cyanided by agitation using countercurrent method.

Mine: From the main haulage tunnel level, a cross-cut tunnel connects with Lodestar Mine workings, also with Soledad Extension Mine as the ore from these two properties is being treated under contract in the company's mill. One hundred and fifty men are employed.

Bibl.: State Mineralogist's Report XXXI, pp. 475-479.

Gum Tree Mine. It comprises 3 claims situated on Bowers Hill, adjoining Exposed Treasure Mine, on the east, in Sec. 32, T. 11 N.,

R. 12 W., 4 miles south of Mojave; elevation 2800 ft.; owner, Jessie Knight, Mojave, Calif.; under lease to H. E. Robinson.

The vein strikes N. 30° W.; dip 60° E.; width 4 ft. to 6 ft. Development consists of two shafts sunk to a depth of 200 ft., with levels at 100 and 200 ft. and about 1000 ft. of cross-cuts and drifts.

Equipment consists of hoists and compressor, gasoline-driven. Six men are employed. Production amounts to 50 tons a month which is shipped to Burton Bros., Inc. for treatment.

Gwynne Mines comprise 445 acres of patented claims situated in the Green Mountain Mining District, in Sec. 21 and 22, T. 34 E., M. D. M., 25 miles northeast of Caliente and 3 miles northeast of Piute; elevation 750 to 8000 ft.; owners, Otto G. and James C. Geringer, Chicago, Ill.

Three parallel veins occur in granite known as Jennette, Gwynne and Kersey. Gwynne and Jennette veins strike east and west and dip 40° S. Width varies from 12 in. to 2 ft. Kersey vein strikes N. 45° E. and dips 40° SE.; width 2 ft. to 4 ft. Present work is confined entirely to the Gwynne and Kersey veins. The main working tunnel on the Gwynne vein is driven east 1750 ft. At 1500 ft. from the portal, a winze has been sunk on Gwynne vein to a depth of 225 ft. At 1600 ft. from portal, a cross-cut has been driven east 100 ft. to the Kersey vein, with drift southwest 300 ft. and northeast 150 ft. The Kersey vein is 4 to 8 ft. in width, with a porphyry filling, reported to have an average value of $6 per ton in gold. The property is operated during the summer months.

Mine run of ore to mill: 25-ton ore bin to 6 by 8-in. Blake crusher, 4 by 4-ft. Hendy ball mill. Product from ball mill is elevated by bucket elevator to Cottrell vibrating screen and screened to minus 40-mesh. Oversize is returned to ball mill. The minus 40-mesh product goes to Senn amalgamator; pulp from amalgamator to Wilfley concentrator. Mill has a capacity of 25 tons per day. Six men are employed.

Mine equipment consists of Ingersoll-Rand compressor, air drills and cars.

Bibl.: State Mineralogist's Reports XII, p. 146; XIII, p. 192; XIV, pp. 498-499; XXV, pp. 36-37; XXIX, pp. 307-309.

Keyes Mine. It comprises 13 claims, totaling 260 acres, situated in Sec. 26, T. 26 S., R. 32 E., M. D. M., in Keyes Mining District, 3 miles southeast of Isabella; elevation 3600 ft.; owner, *Kern River Mining Co.*, A. A. Cash, secretary; office address, 2240 San Fernando Blvd. It is under lease and bond to Fred K. Seaman and A. Swift, of Los Angeles; Jerry Saunders, superintendent, Isabella, Calif.

Five parallel veins occur in granite. Present work is being confined to Keyes vein which is from 12 in. to 2 ft. in width; strike N. 45° E., dip 70° SE. Development consists of a cross-cut tunnel driven west 840 ft. to the vein, with drift southwest 1400 ft. on the Keyes vein. At 1200 ft. southwest of cross-cut tunnel, a winze is sunk on the vein to a depth of 100 ft., with 700 ft. of drifting on 100-ft. level.

Mine equipment consists of a Chicago pneumatic compressor, with a capacity of 300 cu. ft. per minute. Mill equipment consists of ten 1000-lb. stamps, amalgamation plates and two concentrators. Mill

is driven by General Electric motor. Ten men are employed on development work.

Bibl.: State Mineralogist's Reports XXV, pp. 37-38; XIV, p. 499; XIII, p. 191; XII, p. 145; XXIX, p. 311-312.

King Solomon Mine. It comprises 5 patented claims situated in Sec. 25, T. 29 S., R. 40 E., M. D. M., in the Rand Mining District, three-quarters of a mile west of Johannesburg; elevation 3900 ft.; owner, *Shipsey Mining Co.*, Ed Shipsey, president, 610 South Olive St., Los Angeles; under lease to J. B. Nosser, Jr., Randsburg, Calif.

There are 4 veins in the schist. These veins vary in strike from N. 35° W. to N. 80° E., while dips range from 40 to 50° to the northeast. The property is developed by a 2-compartment shaft which is sunk on inclination of 45° to a depth of 700 ft., with seven levels and about 11,000 ft. of drifts and cross-cuts.

Mine equipment consists of electric-driven hoist, compressor and air drills. Mill equipment consists of 6 by 10-in. Dodge crusher, Challenge ore feeders, fifteen 1000-lb. stamps, amalgamation plates, 4 ft. by 6-ft. Traylor ball mill, 24-ft. Dorr thickener, Groch flotation machines and cyanide tanks. Capacity of mill is 50 tons per day. Twenty men are employed.

Bibl.: State Mineralogist's Reports XIV, p. 500; XXV, p. 38; XXIX, pp. 313-314.

Lode Star Mine (Elephant-Eagle). The property is situated on the northwest slope of Soledad Mountain, in Sec. 6, T. 10 N., R. 12 W., 4 miles southwest of Mojave; elevation 3000 ft. to 5000 ft. Holdings comprise 220 acres; owner, Lode Star Mining Co., John Rogers, vice president and general manager; William Benham, superintendent; offices, Mojave, Calif.

Since the XXXI Report of the State Mineralogist, pp. 472-474, all development has been confined to the Echo-Gray Eagle and Starlight veins, these being three parallel veins which occur in dacite. The general course of the veins is northwest. The Starlight vein dips 70° W., the others to the northeast. The veins vary in width from 7 ft. to 25 ft. Gold occurs free, associated with pyrite. The silver occurs as cerargyrite (horn silver). The ore mined is said to carry 70% in gold and 30% in silver. At an elevation of 3638 ft., No. 1 tunnel level is driven on the Starlight vein southeast 800 ft. At an elevation of 3538 ft., the Gray Eagle or No. 2 tunnel level has been extended southeast 3000 ft. At about 2000 ft. from the portal, the south ore shoot was intersected southeast of fault. The ore shoot developed is about 900 ft. in length, with an average width of 13 ft. At 2100 ft. southeast of the portal, a winze has been sunk on the hanging wall of the vein to a depth of 250 ft. At an elevation of 3355 ft., No. 3 tunnel is driven southeast 2500 ft. At an elevation of 3180 ft., No. 4 tunnel level is driven N. 25° W. to the Starlight vein, then southeast about 1500 ft. A cross-cut haulage tunnel from Golden Queen connects with No. 4 tunnel level. About 5000 tons per month are mined and treated in the Golden Queen mill. Total amount of ore mined to date is 100,000 tons.

Mine equipment consists of Ingersoll-Rand compressor and complete blacksmith shop. Fifty-two men are employed.

Bibl.: State Mineralogist's Report XXXI, pp. 472-473.

Master Key Mine. It comprises 4 claims, situated in the Rand Mining District, adjoining the Big Dike and Yellow Aster claims on the west and north in Sec. 34, T. 29 S., R. 40 E., M. D. M., one mile south of Randsburg; elevation 3600 ft.; owner, Edward Herkelrath, Randsburg, Calif.; under lease to Wade & Wade, Randsburg, Calif.

Two systems of veins occur in a rhyolite dike in monzonite. The dike strikes NE. and SW. On the north side of the rhyolite dike, there is a series of northwest-southeast veins in monzonite. The east-west veins occur in rhyolite. Development consists of four shafts, two of which are 25 ft. deep. The other two have depths of 50 ft. There is a drift 60 ft. in length between the two 50-ft. shafts. Ore mined and sorted from these workings is reported to carry $50 per ton. It is reported that $5000 worth of ore has been shipped from the property. Five men are employed.

Milwaukee Mine. It comprises 610 acres situated on the west slope of Hamilton Mountain, in Sec. 16, T. 9 N., R. 13 W., 1½ miles west of Tropico and 7 miles west of Rosamond; elevation 2850 ft.; owner, Milwaukee Mining Co., Wisconsin; under lease to *Seward-Bradley Mining Co.*, P. B. Seward, president, Los Angeles; D. A. Bradley, secretary and manager.

The vein occurs in dacite, strikes E.-W.; dip 60° S.; width 4 ft. to 6 ft. Former workings of Milwaukee group were in the NW. ¼ of Sec. 16 and consisted of 3 shafts: 2 vertical shafts, one 85 ft. and the other 310 ft.; on the 200-ft. level, cross-cut north 250 ft. and 250 ft. of drifts; also an incline shaft 140 ft. deep. All workings are caved. West of these workings at a higher elevation, the present company has sunk an incline shaft 250 ft. in depth, with a cross-cut north on the 200-ft. level.

Equipment consists of Gardner-Denver compressor, driven by 20-h.p. gas engine; 10-h.p. gas engine hoist. Idle.

Monarch Mine (Extension Ajax). It comprises one claim (740 ft. wide by 1687 ft. in length), in Sec. 5, T. 10 N., R. 12 W., M. D. M., on the southeast slope of Soledad Mountain, 4 miles south of Mojave, Calif.; elevation 3760 ft.; owner, Wilcox Estate, Bakersfield, Calif.; under lease to the *Golden Age Mining Co.*, E. Riveroll, president and manager, Los Angeles. During 1937, the property was under lease to the *Mojave Gold Shares, Inc.*, a Nevada corporation. This company drove the main cross-cut tunnel to cut the Ajax and Karma veins. The property adjoins the Karma Mine on the south.

The Ajax vein strikes N. 20° W. and dips 60° W. It is in dacite. Development consists of a cross-cut tunnel driven S. 74° W., 587 ft.; 294 ft. west of portal, intersected the Ajax vein which at this point is 18 ft. wide; at 542 ft. cut the Karma vein which has a width of 45 ft. On the south end of the property, the Ajax and Karma veins are cut off by a fault which strikes east and west. About 400 ft. north of these workings considerable trench work and open-cuts have been

made along the Ajax vein, exposing 10 to 18 ft. of quartz which is reported to average $5 per ton in gold and silver. About 100 ft. below outcrop, a cross-cut tunnel has been driven west 100 ft. intersecting the vein.

Four men are employed on development work.

Mohawk-Buddy Mine. It comprises 11 claims, situated in Butterbread Canyon, near the San Antonio Mine, in El Paso range of mountains, 11 miles northeast of Cantil; owners, W. E. Russell and associates, Cantil, Calif.

Two veins occur in granite. One strikes NE.-SW.; dip 70° NW.; width 5 ft. Two shafts are sunk on the vein to depths of 50 and 70 ft. The other vein strikes E.-W.; dip 65° S.; width 2 ft. to 4 ft. A tunnel is driven on this vein a distance of 287 ft.

Equipment consists of 6-h.p. hoist and Sullivan portable compressor. Two men are employed on development work.

Operator Consolidated Mines. The property comprises 7 claims, 140 acres, patented, located in Sec. 35, T. 29 S., R. 40 E., one-half mile north of Johannesburg; owner, Operator Consolidated Mining Co., E. A. Weller, president; H. G. Hunt, secretary and manager, 1214 Sierra Ave., San Jose, Calif.

Five veins have been developed on the property; strike NW.-SE., with a dip of 20° N.E.; widths 2 ft. to 12 ft. The formation is schist, although in places rhyolite and diabase dikes occur as walls of the veins. The ore is oxidized and free-milling. The Phoenix vein is developed by an incline shaft to a depth of 300 ft., with 6 levels and some 2000 ft. of drifts.

Present development work is on the Styx Claim and consists of cross-cut tunnel driven 400 ft. to vein, developing an ore shoot 100 ft. in length and 6 to 12 ft. wide. Finger winzes have been sunk on the vein at this point. Mine run of ore goes to 15-stamp mill, treatment being amalgamation and cyanide. Plant has a capacity of 25 tons per day. Water is secured from Little Butte Mine; electric power from Southern Sierra Power Corp. Sixteen men are employed.

Bibl.: State Mineralogist's Reports XIV, p. 507; XXV, pp. 43-44; XXIX, p. 321.

Pride of Mojave Mine. It comprises 65 acres in Mojave Mining District, in Sec. 33, T. 11 N., R. 12 W., S. B. M.; also a lease on the Desert Queen and Hobson claims consisting of 40 acres; owner, *Standard Mining & Milling Co.* These claims are in Sec. 32, T. 11 N., R. 12 W., S. B. M., on the east slope of Bowers Hill, 4 miles south of Mojave; elevation 2700 ft.; owners, Alfred Sieman, Bakersfield, Calif., and C. C. Calkins, Los Angeles; under lease and bond to Pride of Mojave Mining Corp.; George H. Barnes, president; Floyd Yancey, secretary, John Dewar, vice president and general manager; John J. Murray, superintendent; offices, Van Nuys Bldg., Los Angeles.

The property has been developed by three shafts; the Pride of Mojave shaft sunk to a depth of 265 ft., on an inclination of 65°; the Desert Queen shaft 400 ft. on 70° inclination and the Four Star shaft, sunk to a depth of 400 ft., vertical. Levels have been driven at the 70, 130 and 230-ft. horizons in the Pride of Mojave shaft,

with a total of about 4000 ft. of workings. On the 300-ft. level in the Four Star shaft, a crosscut has been driven west 365 ft. to the Desert Queen vein, with a drift south on the vein 220 ft. At the end of the crosscut there is a raise which connects with the fourth level of the Desert Queen. On the 400-ft. level there is a crosscut 150 ft. to the vein, with a drift south 50 ft. The vein is said to average 4 ft. in width, with a reported average value of $7.50 per ton.

At the Pride of Mojave shaft, the mill has been erected equipped as follows: 400-ton coarse-ore bin, 10 in. by 10 in. jaw crusher, 18-in. belt conveyor to Vezin samplers ($\frac{1}{2}$ of 1 per cent sample) to 200-ton fine-ore bin, belt feeder to 6 ft. by 5 ft. ball mill, Dorr type of duplex classifier, 16-ft. Dorr thickener, 6 ft. by 6 ft. condition tank, to Denver Sub-A flotation rougher cells and one Sub-A cleaner cell and Plat-O table. Machines have individual electric motor drives, using a total of 380 h.p. About 25 men are employed.

Bibl.: State Mineralogist's Report XXXI, pp. 481, 482.

Sky Line Mine. The property comprises 8 claims, situated in Pine Tree Canyon, 15 miles north of Mojave and 3 miles west of the Owens Valley highway; elevation 4000 ft.; owner, Verne Moore and associates, Cantil, Calif. The property is under lease and bond to *Piute Mining Co.,* W. H. White, president; O. W. Crockett, secretary, Seattle, Wash.; William J. Quackenbush, general manager, 917 Ronan Bldg., Wilmington, Calif.

The country rock is quartz monzonite. The principal vein strikes N. 85° W., dips 70° to 75° NE.; width 2 ft to 8 ft. It is partially filled with quartz. Mineralization consists of sulphides and very little free gold. Principal development consists of two shafts. East shaft is 250 ft. deep, with levels at 75, 140 and 250 ft. On the 250-ft. level, there is a drift west 200 ft. and east 210 ft. At about 100 ft. west of shaft on this level, a fault displaces the vein 60 ft. to the north. The west shaft is 1000 ft. west of east shaft and has been sunk on the vein to a depth of 200 ft., with levels at 100 and 200 ft. About 1200 ft. north of this vein there is a parallel vein whose outcrop is up to 30 ft. wide. This vein is developed by shaft 100 ft. in depth.

The mill which is about $1\frac{1}{2}$ miles down the canyon from the mine consists of the following equipment: No. $2\frac{1}{2}$ Wheeling jaw crusher, 5 ft. by 4 ft. Marcy ball mill, simplex Dorr type classifier, 6 ft. K & K flotation rougher cell and 6 ft. K & K cleaner cell, Wilfley table. Capacity of the mill is 40 tons per day, 20 tons per day being treated. Seven men are employed in mine and 5 men at the mill.

Spangler Mine. The property comprises 18 claims, situated in Sec. 36, T. 27 N., R. 41 E., M. D. M., 6 miles northeast of Searles, a station on Owens Valley branch of the Southern Pacific Railroad; elevation 3600 ft.; owners, S. J. and D. R. Spangler, Johannesburg, Calif., and *Gold Point Mining & Milling Co.,* Bakersfield, Calif. The property is under lease and option to the Spangler Mercury Co., J. M. Quigley, Johannesburg, Calif.

The property was located in 1896 and has been held by the Spangler brothers since that date. The country rock is a coarse-

grained diorite in which occurs an east-west vein, intersecting a north-south quartz-filled fracture. The east-west vein, known as the Gold Point, dips 50° S. The north-south vein dips 45° W. The lenticular masses of quartz in the veins are from 12 in. to 3 ft. wide. Shipments aggregating 500 tons of ore have been made from the property, reported to have carried $40 per ton in gold. Principal development has been on the Gold Point vein. It consists of a shaft sunk on the vein to a depth of 175 ft., with drifts on the 75 and 150 ft. levels. Total development amounts to 2000 ft. Mill consists of 40-ton ore bin, 8 in. by 10 in. jaw crusher, 4 ft. balanced rod mill, 4 ft. by 8 ft. amalgamation plates and concentrating table. Mill is driven by gasoline engines. Five men are employed.

St. John Mine. The property comprises 6 claims situated in Sec. 33, T. 28 S., R. 35 E., M. D. M., in the Sageland Mining District, 20 miles southeast of Weldon and 3 miles south of Tunnel Springs, on the Kelso Valley road; elevation 5400 ft.; owner, Karl Struse, Hollywood, Calif.

Two veins occur in granite strike N. 50° W. and dip 35° SW.; width 6 in. to 4 ft. The development consists of two shafts, one 330 ft. in depth and the other 700 ft. in depth; both sunk on the St. John vein. These two shafts are connected on the 230 ft. and 330 ft. levels.

A 25-ton amalgamation and cyanide plant has been installed near Tunnel Springs. Some ore was treated from the dump but was not found to be of commercial grade. Idle.

Bibl.: State Mineralogist's Reports XXV, p. 48; XXIX, pp. 327-328.

Tropico Mines. The property comprises 11 patented claims, 220 acres, and two 5-acre mill sites, situated in Sec. 10, 11, 14 and 15, T. 9 N., R. 13 W., S. B. M., 5 miles northwest of Rosamond; elevation 2800 ft.; owner, *Burton Bros., Inc.*, H. Clifford Burton, president; George McNamee, secretary, Tropico, Calif.

The vein system consists of 6 parallel veins that follow fault fissures in rhyolite. These veins strike east and west, dip 60° S. and have widths varying from 6 ft. to 20 ft.

Development consists of shafts sunk on the Home, Fairview and Lida veins. The principal development work is on the home vein. The main shaft is sunk on an incline of 60° to a depth of 700 ft. The Fairview shaft has a depth of 300 ft. and the Kid shaft has a depth of 250 ft. The total amount of development work on the property amounts to about 6000 ft. of crosscuts and drifts.

Mill: (since State Mineralogist's Report XXXI, pp. 483-485); the mill capacity has been increased to 100 tons per day, with the installation of a Symons cone crusher.

During 1938 the company milled 26,308 tons of ore; recovered 10,165 oz. in gold. The average grade of the ore milled was reported to be $12.50 per ton. During 1938, ninety-four individual shippers hauled ore to the mill for treatment. Besides custom ore received from the Mojave District, ore was shipped from mines in Inyo, Kern, San Bernardino and San Diego counties.

The production from the company's mine is about 2000 tons per month. They also handle 1000 tons of custom ore per month. Fifty men are employed.

Bibl.: State Mineralogist's Reports XIV, p. 512; XXV, pp. 50-51; XXIX, p. 331; XXXI, pp. 482-484.

Whitmore Mine. It comprises 10 claims, situated in the Mojave Mining District, in Sec. 32, T. 11 N., R. 12 W., S. B. M., 3½ miles south of Mojave; elevation 2700 ft.; owner, Whitmore Mines, Inc., Walter E. Trent, president, Washington, D. C.; George J. Andersch, vice president; C. D. Wilkerson, manager, Mojave, Calif.; offices, 405 South Hill St., Los Angeles.

Four parallel veins occur on contacts with granite and rhyolite porphyry. The veins strike N. 30° W.; dip 60° E. Veins vary in width from 2 ft. to 6 ft. Developed by three shafts, 300, 280 and 200 feet in depth.

Present operators are shipping ore from the 100 and 200-ft. levels of the 300-ft. shaft and also drifting south on these levels. Shipments to the Golden Queen mill have totalled 1000 tons since November, 1938.

The property is equipped with electric hoists and electric-driven compressor. Ten men are employed.

Bibl.: State Mineralogist's Reports XIX, pp. 152-153; XXV, p. 52; XXIX, pp. 334-335; XXXI, pp. 484-485.

Yellow Aster Mine at Randsburg was taken under lease and option by the *Anglo American Mining Corp., Ltd.*, W. L. Brown, president; L. M. Davis, secretary; A. W. Frolli, general manager, 1005 Mills Bldg., San Francisco, from the *Yellow Aster Mining & Milling Co.*, of Los Angeles, in 1933.

Discovery of gold on this property in 1895 marked the beginning of the town of Randsburg. Since that time there have been several stages of development and mill operations. The first ore mined was treated in a small mill at Garlock some nine miles northwest from the mine. Later, ore was shipped to a mill at Barstow. In the late nineties, a 30-stamp mill was erected at the property, followed by a 100-stamp mill about 1900.

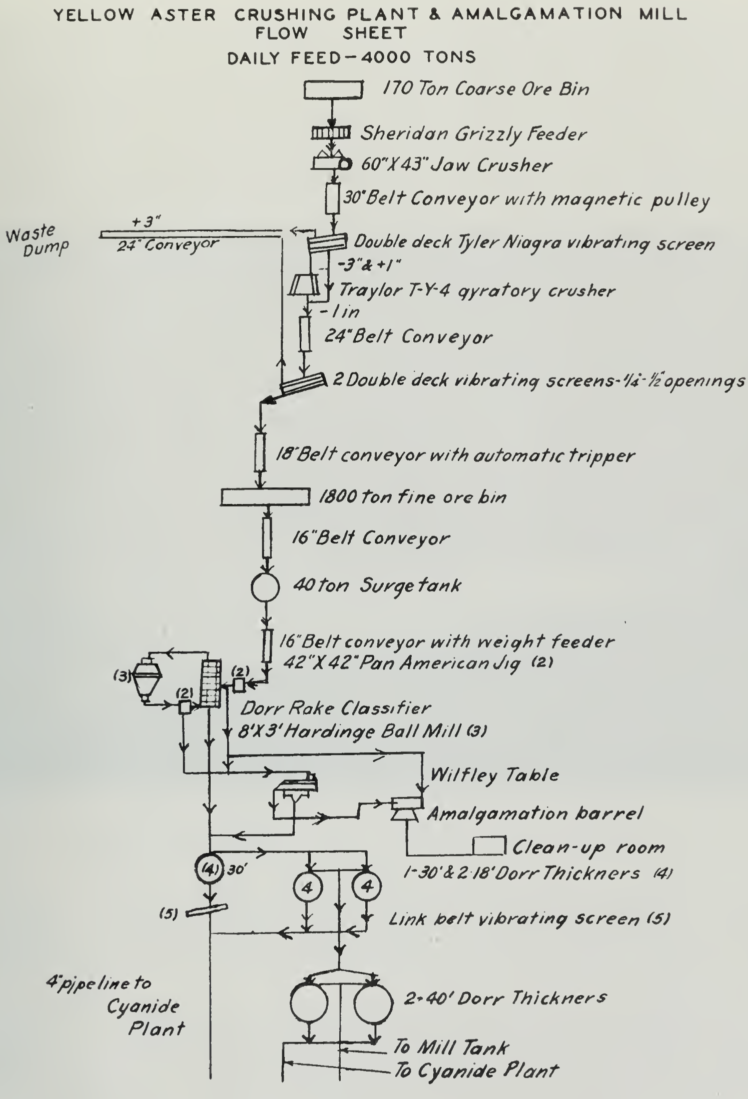
The mine operated continuously from 1895 to the latter part of 1918 when it was shut down, reopening in 1921. From this time until the property was taken over by the present lessee (October, 1933), a large part of the ore was mined by lessees and treated together with company ore by fifty stamps of the 100-stamp mill. During this period (1895-1933) approximately $10,000,000 was recovered from about 2,750,000 tons. These values were recovered entirely by the use of both inside and outside amalgamation.

The mine lies in the quartz monzonite schist complex near the top of the Rand Mountains, just south of Randsburg. The ore occurs in a triangular block of quartz monzonite which is bounded by three faults, namely, the Hanging Wall Fault on the east, the Jupiter Fault on the north and the Footwall Fault on the southwest. The first two are described by Hulin[1] as premineral faults. The ore occurs in a network of quartz stringers traversing the quartz monzonite as well

[1]Hulin, Carlton D., Calif. State Mining Bureau Bull. 95, pp. 122-123.

as in the rock adjacent to the veins. Early operations were largely confined to high-grade orebodies occurring in vertical fissures and beneath the two premineral faults.

The vertical fissures strike northwest and vary in width up to more than 15 ft. and in length up to 800 ft. as mined in the East and



West sets. To the northeast is the Rand vertical vein; while between the two, is the Price vein. All of these veins, together with several others, were bounded by the Jupiter and Footwall faults.[2]

[2] For more complete description of the orebodies refer to U. S. G. S. Bull. 430, pp. 25-31, by F. L. Hess and Calif. State Mining Bureau Bull. 95, pp. 122-124, by Carlton D. Hulin.

The orebodies underlying the Jupiter and Hanging Wall faults have a well-defined hanging wall but an assay footwall. They were from 200 ft. to 500 ft. long and from 4 ft. to 16 ft. thick, the greater thickness occurring nearest the surface.

The values in these richer orebodies are not known but the average value of ore taken from the stope pillars by leasers was about $20 (one ounce) per ton.

The mine was developed by approximately 15 miles of workings. While there were fourteen different levels in the mine, four of them, the Rand, first, second and third levels were the most important. The Rand which is at the same elevation as the floor of the open pit was the main haulage level and the shafts were sunk from this level. The main shaft was sunk on the Foot Wall Fault, with an inclination

Photo by Walter W. Bradley

Open-cut at Yellow Aster Mine, Randsburg, Kern County.

of 45°, a distance of 250 ft. The Hercules shaft, located between the Jupiter and Hanging Wall faults, was put down 450 ft., inclined at 40°. The Rand vertical shaft, 150 ft. southwest of the Hercules shaft, is down 450 ft.

The present operators have abandoned the underground workings and are taking their ore from the glory hole or open pit (which it now is). This open pit is approximately 1250 ft. long by 800 ft. wide, at its top and varying from 100 ft. to 400 ft. in height.

Mining and hauling to the mill is done by contract; the total cost is 18¾¢ per ton.

Both toe-hole and coyote blasting are used in breaking down the sides of the pit. The holes are usually about 30 ft. deep. The coyote tunnels are, of course, varied to suit conditions; one shot recently fired used 19 tons of low-grade powder and broke 120,000 tons.

A model 80, $2\frac{1}{2}$-yd. Northwest shovel is used for loading after the bulldozer has cleaned up the floor of the pit. The material is hauled one-quarter of a mile to the mill by four $3\frac{1}{2}$-ton, 6-wheel trucks. About 4000 tons per day are handled. Large boulders of granite and schist are hauled direct to waste dump. In the past, the waste thus handled has varied from 100 to 6000 tons per month.*

Milling Operations: The present operators made extensive tests on the ores of the open pit and the dumps. During these tests something over 120,000 tons were put through, using both single and two-stage crushing and screening. As a result of these tests, the following plant was constructed (completed about Jan. 15, 1938): (see flow sheet).

Trucks dump onto grizzly with 30-in. sq. openings to 170-ton bin, to grizzly feeder (5 in. by 7 in. openings); oversize to 60 in. by 48-in. jaw crusher; undersize and crusher product to 30-in. conveyor, with magnetic pulley, to double deck vibrating screen 3-in. sq. openings; oversize to 24-in. conveyor (No. 3), oversize from lower deck to 4-ft. TY gyratory crusher; undersize and crusher product to 24-in. conveyor (No. 2), to 2 double deck vibrating screens, lower decks having $\frac{1}{4}$-in. by $\frac{1}{2}$-in. openings; undersize to 18-in. conveyor (No. 8), to 1800-ton mill bin; all oversize to No. 3 conveyor; thence by a system of three 24-in., one 24-in. shuttle and one 24-in. stacker conveyor to the waste dump.

Dust is controlled by a system of spray nozzles placed at strategic points. Capacity of the plant is 300 tons per hour.

From the 1800-ton fine-ore bin, material is delivered onto a 16-in. conveyor through any of 8 chutes equipped with rack and pinion gates, to a 45-ton surge bin, to a Hardinge constant-weight feeder to 16-in. conveyor, automatic sampler to No. 1 Pan American placer-type jig; concentrates to sand pump to No. 6 Wilfly table; concentrates to continuous amalgamation barrel to retort; tails from jig, Wilfley table and barrel to duplex rake classifier; overflow to tails launder; sands (with added lime and cyanide) to 8 ft. by 36 in. Hardinge mill to No. 2 Pan American placer-type jig; concentrates go with No. 1 jig concentrates; No. 2 jig tails to tailings launder; automatic sampler to 30-ft. Dorr type thickener; overflow to two 18-ft. Dorr-type thickeners; underflow from the three thickeners to vibrating screen (6 mesh); oversize to waste screenings to 4-in. pipe to cyanide plant; overflow from 18-ft. thickeners to two 40-ft. Dorr type thickeners; underflow to cyanide plant; overflow to 2 centrifugal pumps, back to mill circuit. Capacity of classifying and concentrating plant is 1000 tons per day.

A total of nineteen men are employed on the three shifts.

Cyanide Plant: The current mill tailings are delivered to the cyanide plant through a 4-in. pipe line 2740 ft. long. Old mill tailings, of which there are some 2,000,000 tons, are sluiced with cyanide solution. The solution is pumped from cyanide plant through an 8-in.

* Since the above was written, the Anglo American Mining Corporation has canceled and released to the Yellow Aster Mining and Milling Company its lease contract to the mine and mill and property adjacent thereto. Walter L. Brown, president, states that the discontinuance of mine and mill operations had been contemplated, owing to low values, but that the actual shutdown was hastened by a strike called December 1 by employees. Operation of the cyanide plant may be continued.

pipe line to a 21,000-gal. tank. Solution from this tank is pumped to the mill. Connections for 2-in. or 3-in. pipe are provided in the 8-in. line. To short sections of these pipes are attached 2-in. rubber covered hoses equipped with $\frac{5}{8}$-in. or $\frac{3}{4}$-in. nozzles. The pressure varies up to 90 pounds. The bank sluiced varies from a few feet to 100 or more in height.

The tailings are sluiced to a pump sump where a 6-in. Wilfley sand pump delivers them to the cyanide plant through 850 ft. of 5-in. pipe.

Both current and old mill tails are delivered to a 12-ft. by 6-ft. surge tank. Cyanide and lime are added at the pump sump.

From surge tank to two 6-ft. by 23-ft. Dorr classifiers, overflow to hydro-separator (60 ft. dia. by 12 ft. depth); overflow from separator to 4-in. sand pump to 100-ft. center pier Dorr type thickener; underflow from 100-ft. thickener pumped to three 14-ft. by 14-ft.

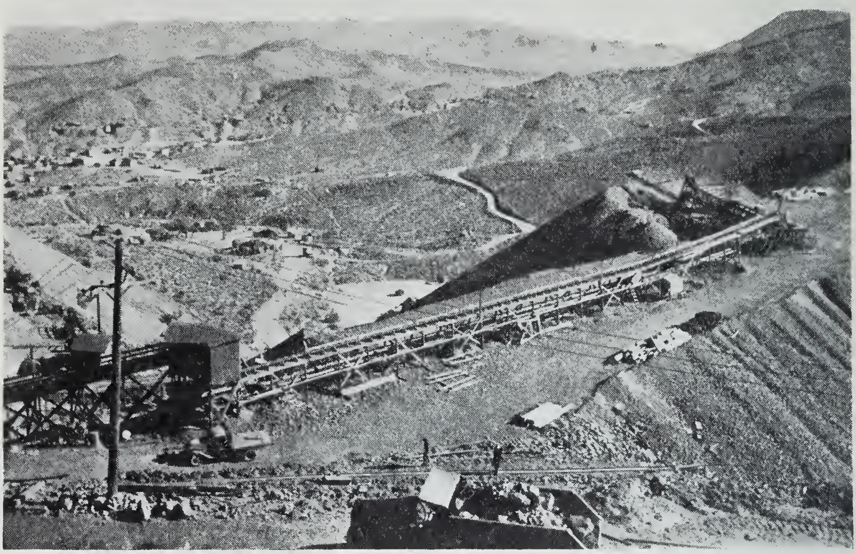


Photo by Walter W. Bradley

Conveyor belt for waste rock disposal at mill of Yellow Aster Mine, Kern County. Town of Randsburg in left-middle distance.

Oliver filters; overflow from 100-ft. thickener pumped back to classifiers; underflow from hydro-separator by 4-in. sand pump to two 60-ft. by 12-ft. primary thickeners; overflow pumped to sand tanks; underflow from thickeners pumped (2-in. sand pump) to three 16-ft. by 14-ft. Dorr agitators in series; from the third agitator the pulp is further diluted with barren solution and caustic starch to aid settling and flows to two 60-ft. by 10-ft. washing thickeners; overflow is pumped to storage tanks for use in mill or for sluicing old tailings; underflow from thickeners is pumped, part to filters and part to tailings pond (capacity of filters usually limits that part to about 70%); filter cake goes to blade-type repulpers, is diluted with fresh water to about 30% solids and is pumped by 3-in. sandpump either to sand tanks for

sluicing or to tailings pond. Filtrate from the filters is pumped to head end of sand plant.

Sands from the two 6-ft. by 23-ft. classifiers are treated in eight 45-ft. by 12-ft. sand tanks, filled in rotation. A rubber lined launder feeds the tanks and the pulp is distributed by a revolving launder, pivoted at the center of each tank. Slimy overflow, while filling, is removed by a 6-in. pipe; tanks are drained through a 3-in. pipe and sluiced out through an 8-in. opening in the bottom. Usually one tank is filled each day. Pregnant solution from sand tanks is pumped to precipitation plant. Solution is clarified in two tanks equipped with Butters type leaves. The leaves are connected to a Crowe deaerating tower, from which the solution is drawn by 4-in. centrifugal pump and forced through 240 precipitate collecting bags which are placed in 4 tanks, 60 to each tank. Zinc dust is fed into the suction pipe of the pump. Normally about 2750 tons of solution are precipitated per day.

Capacity of cyanide plant is 1500 tons per day. Fresh water is pumped from Goler, a distance of 6.9 miles, through a 6-in. line.

Electric power is used throughout the plants, machines having individual motor drives. Power is bought from Nevada-California Power Corp. Total power requirements are about 1440 h.p.

There are 45 men on the payroll; 11 men at the crushing plant; 8 in the mill; 5 sluicing tailings; 17 men at the cyanide plant; 4 general outside work.

Costs are about as follows: Mining 0.1875 (about 60¢ per ton milled); crushing and milling 0.30; cyanidation 0.25; total $1.15 per ton milled. Crushing and screening plant handles 3000 tons in two 8-hour shifts. Grinding plant treats 1000 tons of ore in 24 hours. The cyanide plant has a capacity of 1500 tons in 24 hours. Total operating costs are reported to be 40 cents per ton. Forty men are employed.

Bibl.: State Mineralogist's Reports XIV, p. 514; XXV, pp. 53-54; XXIX, pp. 335-338; Bull. 95, pp. 121-125; U. S. Bureau of Mines Inf. Circ. 6900, Mining & Milling Methods & Costs; also I. C. 7096 on Open-pit Operations.

LOS ANGELES COUNTY

Governor Mine (New York), consisting of 4 claims, is 3 miles north of Acton and 20 miles east of Saugus, in the Cedar Mining District; elevation 3000 ft.; owner, Governor Mining Co., Chas. H. McWilliams, president; J. F. Gage, secretary and general manager, 725 South Figueroa St., Los Angeles.

This property has been the largest gold producer in Los Angeles County, having been worked intermittently since about 1880.

The vein is a quartz-filled fissure in quartz diorite. The strike is N. 20° W. and it dips 65 to 75° NE. Its width varies up to 24 ft., the average being about 7 ft. Gold occurs free and associated with pyrite. The ore-shoot as now opened from the 200 level to the 700 level, shows a length of about 400 ft. The mine is developed by a main working tunnel 800 ft. in length from which a vertical shaft has been sunk 720 ft., with levels at 100, 200, 300, 400, 450, 500, 600

and 700 ft. horizons. Drifts have been driven on the various levels as follows:

Level	Feet	Feet
100	N. 210	S. 65
200	N. 212	S. 227
300	N. 196	S. 263
400	N. 130	S. 329
450	N. 81	S. 294
500	N. 115	S. 309
600	N. 100	S. 215
700	S. 38	

The vein crossed the shaft at about 540 ft. and on the 600 level, the crosscut west is 40 ft. to the vein, while on the 700, it is 86 ft. west to the vein. Stoping operations have been carried on from the 600 level up but above each level there still remains unbroken ore. Shrinkage method of stoping is used and it is reported that there are now 10,000 to 12,000 tons broken in the stopes. It is also reported by the operators that there are approximately 90,000 tons of ore available from the present workings.

At the mine, in addition to compressor, blacksmith shop, change house and office, there is a 9 in. by 12-in. jaw crusher, 15 in. by 26.-in rolls, belt conveyor to 400-ton bin. From this bin the ore is hauled by trucks 4 miles to the mill which is about one mile south of Acton.

The new mill, having a capacity of 120 tons per day, has been completed only about 3 months (August, 1939) and consists of the following: 200-ton bin, belt feeder to 5 ft. by 6 ft. ball mill, trap, to Dorr-type duplex drag-classifier in closed circuit, to 4 corduroy tables 30 in. by 18 ft. to 7 ft. diameter conditioner. From conditioner, feed is split to two sets of Denver Sub. A type flotation cells, each set consisting of two roughers and one cleaner cell. This mill is under the same roof as the old one which has a capacity of 30 tons per day. All machines are motor-driven. Ratio of concentration is 46 to 1. Seventy-two per cent of the gold is recovered in the trap and on the corduroy. An extraction of approximately 94% is indicated. Since reopening the property about 6 years ago, 55,000 tons have been milled. Forty-five men are employed.

Bibl.: (New York Mine) State Mineralogist's Reports IX, p. 192; XV, p. 476; XXIII, pp. 294-295; (Governor Mine) XXXIII, pp. 183-186.

Rogers and Gentry Mine is in the E. ½ of E. ½ of Sec. 27, T. 8 S., R. 16 W., S. B. M., in the south side of the Antelope Valley, 6 miles south of Neenach and 28 miles west of Lancaster. It comprises 160 acres and is patented; owners, W. J. Rogers and R. J. Gentry, Neenach, Calif.

The vein occurs at the contact of granite with limestone and quartzite. Its strike is from N. 25° W. to N. 50° W., dip 45° SW. Its width varies from 2 ft. to 6 ft. The ore is free-milling with a small percentage of pyrite.

Since our last description of this property (July, 1937), the John J. Roskob interests have sunk a vertical shaft 220 ft. and crosscut westerly an unknown distance. This shaft is approximately 100 ft. north of the portal of the main working tunnel and is now full of

water. Apparently these interests have relinquished their lease and option.

A lease has been given to C. J. Peterson, 2102 P St., Bakersfield, Calif., on the first 50 ft. in depth at the old workings. This lessee is now treating dump material in the following described mill on the ground: The mill is portable, being mounted on a truck. Material is hoisted by belt conveyor to crusher whose action is that of a coffee grinder; elevator to impact mill with 16-mesh screen to a conveyor tank, from which it is fed to a mechanical pan 8 ft. in diameter. The capacity is said to be 2 tons per hour. Five men are employed.

Bibl.: State Mineralogist's Report XXXIII, p. 191.

MONO COUNTY

Black Rock Tungsten Mine, comprising 8 claims, is in Sec. 14 and 23, T. 3 S., R. 31 E., M. D. M., 35 miles by road north of Bishop; owner, Archie Beauregard, Laws, Calif.; under lease and option to the *Tungsten Corp. of Calif.*, R. P. Johnson, president, 811 West 7th St., Los Angeles.

The deposit is of the contact metamorphic type, occurring on the contact of limestone and dacite. Its strike is N. 10° W.; dip varies from 20° to 70°. In width it varies from 7 ft. to more than 60 ft. The gangue is largely garnet, with which is associated a little magnetite, calcite and pyrite, with a very small percentage of quartz. The scheelite occurs disseminated through this gangue in small particles.

Developed by two tunnels and a winze 100 ft. below lower tunnel; with a total of approximately 700 ft. of drifts. There are also two small glory holes.

From the mine, an aerial tram 850 ft. long conveys the ore to 100-ton bin; grizzly to gyratory crusher, screens to rolls, ball mill and tables. Concentrates are dried and cleaned by a Stolle electrostatic separator. Capacity of plant has recently been increased to 150 tons per day. About 40 men are employed.

Comanche Mine, comprising 36 patented and 20 unpatented claims, is in Sec. 7, 13, 18, 19 and 24, T. 2 S., R. 31 and 32 E., M. D. M., in the Blind Spring Hill Mining District, about 25 miles north of Bishop; owner, Comanche Mining & Reduction Co., Geo. W. Adams, president, 725 Title Insurance Bldg., Los Angeles; under lease to F. L. Main of Los Angeles with contract to furnish ore to *Mineral Reduction Co.*, C. W. Jones, president, 337 West Ave. 26, Los Angeles.

On this property a series of roughly parallel veins occur in granodiorite. The strike of these veins varies from N. 10° W. to N. 20° W., dip 40° to 45° E. except the Comanche vein which dips 82° E. They vary in width from 2 ft. to 7 ft. Vein filling is quartz, the valuable minerals consisting of an association of antimonial compound of copper, lead and silver. The ore-shoots are formed by a succession of lenses which vary in length, individually, from 20 ft. to 100 ft.

The property has been developed by a series of tunnels and two shafts 750 ft. and 1400 ft. deep, respectively. The Ross tunnel was driven west 4320 ft., cutting the Kerrick vein at 4116 ft. Total workings aggregate several thousand feet. Production from the property has exceeded $2,000,000.

C. W. Jones has constructed a flotation mill near the portal of the Ross tunnel which has a capacity of 100 tons per day. It is reported that they are now adding cyanide equipment.

Bibl.: State Mineralogist's Reports VIII, p. 376; XXIII, pp. 393-395.

Little Bodie Mining Co., George de Wolfe, Sixth and F Sts., Chula Vista, Calif., has 5 claims 10 miles southeast of Bridgeport and 4 miles east of the highway, about 12 miles southwest of Bodie.

Here a quartz vein in diorite strikes N. 60° E.; dip 60° NW.; width 2 ft. to 4 ft. Values largely are contained in the iron sulphides, with a little very fine free gold.

The property is developed by inclined shaft 175 ft. deep. There are levels at 100 ft. and 150 ft.; on 100-ft. level, drift N.E. 60 ft.; on 150-ft. level, drift NE. 135 ft. This drift will be driven an additional 125 ft. to intersection of a cross vein which strikes NW.-SE. Length of ore shoot not determined. Values said to average $12 per ton.

At the shaft 7 men were erecting a mill; 40-ton bin, jaw crusher, 4 ft. by 4 ft. ball mill, drag classifier; 3 Kraut flotation cells; capacity about 30 tons per day; gas engine power.

May Lundy Mine, consisting of 20 claims, is in Sec. 30, T. 2 N., R. 25 E., M. D. M., 5 miles south of Lundy and 6 miles west of Mono Lake Post Office; elevation 9500 to 12,500 ft.; owner, Thomas Hanna, Martinez, Calif.

The mine was discovered in 1879. It was operated continuously until 1898 and intermittently thereafter until 1914 since which time it has been idle.

In 1937 a 140-ton flotation plant was erected on the lake shore to treat the tailings from the old 20-stamp mill, of which it was estimated there were 60,000 tons, carrying $4.23 per ton. These tailings are in the lake and they are pumped to the plant by a 3-in. Byron Jackson pump. They are delivered to 2 storage tanks to duplex Dorr classifier to 5 ft. by 4½ ft. ball mill to 6 Kraut flotation cells to one cleaner cell filter. This plant operated for a short time and was shut down but it expected to resume operations in the near future.

Bibl.: State Mineralogist's Reports VIII, p. 371; XII, p. 180; XIII, pp. 228-229; XV, pp. 170-171; XXIII, pp. 385-386.

Roseklip Mines Co. (Bodie), John Rosekrans, president, Woodside, Calif.; H. W. Klipstein, vice president, Mills Bldg., San Francisco, has leased the property of the *Standard Consolidated* at Bodie from J. S. Cain.

The lessee erected a 250-ton cyanide plant in 1936 and has been treating the dumps on the property. The dump material is loaded into trucks by two power shovels to 36-in. jaw crusher to Hardinge scrubber; the scrubber slimes to Hardinge hydro-separator, fine product to 2 Kraut cells; scrubber tails to Traylor TY crusher to 500-ton crushed ore bin to 6 ft. by 48-in. Hardinge Ball mill to multi-zone Dorr classifier to duplex Dorr classifier; sands to nine 22-ft. by 10-ft. tanks for percolation; slimes to five 16-ft. by 16-ft. agitators; Merrill-Crowe precipitation. Machines have individual motor drives. Extrac-

tion is 82 per cent. Sixty per cent of value is gold, 40 per cent silver. Twenty-eight men are employed.

Bibl.: State Mineralogist's Reports VIII, p. 385; XII, p. 183; XIII, p. 231; XV, pp. 150-158; XXIII, pp. 389-391.

Simpson Mine (Log Cabin and Sunrise Groups), consisting of 17 claims, is in Sec. 1, T. 1 N., R. 25 E., M. D. M., on the east slope of the Sierra Nevada, 2½ miles west of Mono Lake; elevation 9000 ft.; owner, *Mutual Gold Mines, Inc.*, J. E. Steiger, president, 401 Fernwell Bldg., Spokane, Wash.; John Simpson, superintendent. Under option to *Log Cabin Mines Co.* Frank Garbutt, president and manager, 411 7th st., Los Angeles.

On the Log Cabin Group, to which the present company has confined its operations, there are 5 parallel veins which strike north. The walls are slate and quartzite. The veins vary in width from 2 ft. to 6 ft. The vein filling is quartz and the values occur as free gold associated with hematite.

These claims have been developed by a 2-compartment shaft 300 ft. deep, with levels at 75, 125, 200 and 300 ft. A 1200-ft. adit, driven for drainage, connects with the 300-ft. level; in addition to which there are approximately 2000 ft. of drifts on the various levels.

There is a 10-stamp amalgamation mill on the property. They are installing a No. 65 Marcy ball mill equipped with Clark-Todd amalgamator; capacity of plant 100 tons. Thirty men are employed.

Bibl.: State Mineralogist's Reports XV, p. 171; XXIII, pp. 383-384.

RIVERSIDE COUNTY

Black Eagle Mine (lead, silver, copper, gold). The property comprises 7 patented claims and 3 claims held by location, situated in Sec. 30, T. 3 S., R. 14 E., S. B. M., 40 miles northeast of Mecca; elevation 2100 ft.; owner, *Mecca Mines, Inc.,* S. B. Mosher, president, 811 West 7th St., Los Angeles; J. D. Williams, superintendent, Indio, Calif.

The Black Eagle vein strikes N. 70° W., dips 85° N. The vein occurs along a contact of quartzite and diorite. A shaft has been sunk on the vein to a depth of 400 ft. An adit tunnel intersects the shaft 162 ft. west of the portal, at a depth of 80 ft. below the collar, with a total length driven on vein of 500 ft. west. The vein has been drifted on east and west on 100, 200 and 300-ft levels. The vein is from 4 ft. to 10 ft. in width. The vein quartz is mineralized with galena, malachite, azurite, cuprite, anglesite, cerussite and lead vanadate. The ore carries values in gold, silver, copper and lead.

Equipment consists of 300-h.p. diesel engine, direct-connected to generator; electric hoist, compressor and 100-ton concentration plant equipped with ball mill, screens, classifiers, Wilfley tables and Denver Sub A flotation cells.

The water supply is from a well in Pinto Basin, 5 miles from property. Concentrates are shipped to Midvale, Utah. Twenty men are employed.

Bibl.: State Mineralogist's Reports XX, pp. 193-196; XXV, pp. 474-476.

Carr Tungsten Mine. It comprises 4 claims situated in Sec. 31, T. 8 S., R. 3 E., S. B. M., on the south slope of Beauty Mountain, and on the ridge north of Chihuahua Creek, 6 miles northeast of Oak Grove and 9 miles east of Aguanga; elevation 4000 ft.; owner, Frank Carr, Aguanga, Calif.; under lease to A. H. Hyndman, Long Beach, Calif.; office, 330 Broad St., Wilmington, Calif.

The deposit is of the contact metamorphic type, occurring on contact of limestone and granite. The strike is N. 40° E.; dip vertical. The width varies from 8 ft. to 20 ft. The gangue is largely garnet and epidote, with which is associated a little magnetite, calcite and quartz. The scheelite occurs disseminated through this gangue in small particles. The ore mined is reported to carry 1½ per cent WO_3.

Development: There is a shaft 50 ft. deep, an open cut 75 ft. in length and 15 ft. wide. A lower tunnel has been driven as a cross cut north 70 ft. to vein; then drift on the vein N. 40° E., 75 ft. in ore.

Mine equipment consists of Ingersoll-Rand portable compressor, capacity 300 cu. ft. Mine run of ore goes from tunnel to 20-ton ore bin, then by belt feeder to No. 2 Wheeling crusher. It is crushed to ½-in.; then from crusher by belt conveyor to 24-in. rolls; ground material from rolls to vibrating screen; screened to 12-mesh; oversize returned to rolls; minus 12-mesh product to hopper; then to two Economy tables. Concentrate cut off tables reported to carry 65 per cent WO_3. Crusher is driven by 75-h.p. automobile engine and rolls are driven by 85-h.p. automobile engine. Six men are employed.

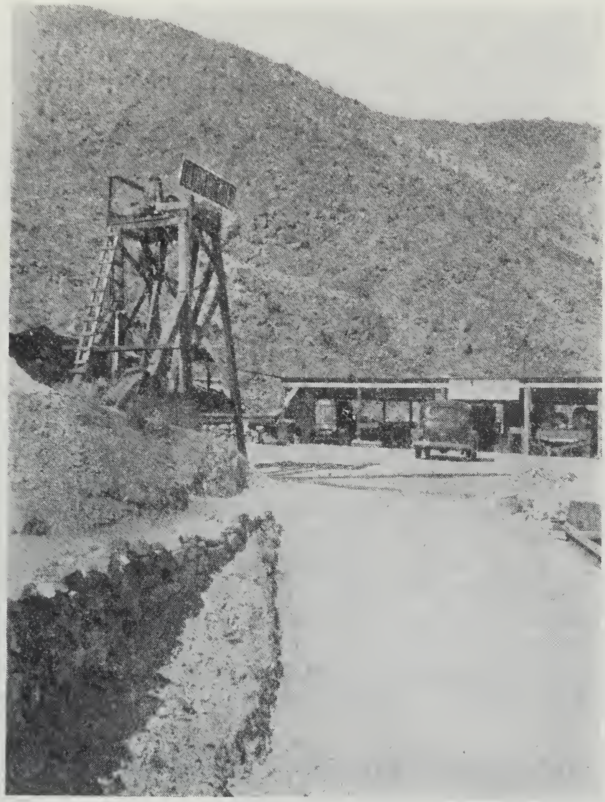
Golden Bee Mine. It comprises 2 claims situated on the north slope of the Hexie Range, in the Piñon Mining District, in Sec. 15, T. 3 S., R. 10 E., S. B. M., 22 miles southeast of Twenty-nine Palms; elevation 3500 ft.; owner, Golden Bee Mines, Ltd., E. Auclair, president and manager; Guy Pierson, San Bernardino, Calif., secretary.

The Golden Bee vein strikes N.-S. and dips 35° E.; width 8 ft. to 30 ft. The country rock is gneissoid granite, with intrusions of diabase forming the footwall of the vein and andesite as hanging wall. About 100 ft. east of the Golden Bee vein is a rhyolite dike 20 to 50 ft. in width that strikes N.-S. and dips 50° E. There is a series of parallel east-west veins that intersect the Golden Bee vein on the west.

The principal development work has been confined to the Golden Bee vein. Irregular shoots of high-grade ore are found in this large vein of quartz. These shoots trend to the northeast about 40°. Widths vary from 12 in. to 2 ft. The Golden Bee vein is a fault fissure with heavy clay gouge on both walls. Development consists of a tunnel driven south 100 ft. on foot-wall of vein with a number of cross cuts driven east. North of tunnel, at the same elevation, a shaft is sunk on an inclination of 85° to 70-ft. level; then sunk on an inclination of 50° to 180-ft. level. On 180-ft. level, drift S. 20 E. 20 ft. from shaft and then a crosscut is driven 80 ft. east to vein. The vein at this point has a width of 30 ft. Ore is stoped from 130-ft. level to the surface, only extracting high-grade lenses in the vein.

Ore shipments made to Burton Bros., Inc., Rosamond, Kern Co. and the Gold Crown Mining Company's mill at Dale, San Bernardino Co., are reported to have been from 1 oz. to 6 oz. in gold per ton. Total production to date $40,000.

Mine equipment consists of 12-h.p. gas-driven hoist; Ingersoll-Rand portable compressor; air drills and truck. Two men are employed.



Golden Bee Mine, Piñon Mining District, Riverside Co.

Golden Rod Mine. The property comprises 2 claims and mill site, situated in Dale Mining District, 40 miles north of Mecca; owner, O. K. Mining Co., Joseph Ingersoll, president; J. S. Bird, secretary; under lease and option to the *Pinto Basin Mining Co.,* C. Carlton, president; Wm. Lesher, secretary; R. D. Lamme, superintendent, Indio, Calif.

The vein occurs in granite, strikes N.-S. and dips 80 W.; width 2 ft. to 4 ft. A shaft is sunk on the vein to a depth of 350 ft. Drifts have been driven north and south on the following levels: 40, 80, 130, 200, 250, and 350 ft. On the 200-ft. level, drift north 300 ft. and south 50 ft.; on 250-ft. level, drift north 65 ft.; south 65 ft. on 300-ft. level; north 75 ft. and south 100 ft. Ore shoot developed is 75 to 100 ft. in length; average width 4 ft. Ore mined from 300 and 350-ft. levels is being shipped to the Gold Crown Mining Company's mill for treatment. The ore is reported to carry from 2 oz. to 4 oz. in gold.

The mill on property has a capacity of 10 tons; 6-in. by 8-in. jaw crusher; 3-ft. by 9-ft. Straub ball mill, with classifier head; two 3 by 5-ft. amalgamation plates. Water is hauled from Lane well in Pinto Basin. Eight men are employed.

Gold Standard Mine (Standard-Duplex). It comprises 4 claims situated in the Dale Mining District, on the south slope of the Dale Hills, 40 miles north of Mecca; owners, E. Allen and Joe Geiger, Indio, Calif.

Vein of quartz occurs in granite; strike N.-S.; dip 80° W. Width varies from 2 ft. to 4 ft. Developed by tunnels 40 ft. to 50 ft. in length and shafts 50 ft. to 100 ft. in depth. They are installing a 2-stamp mill. Four men are employed.

Ida-Leona Mine (Gavalan). The property comprises 360 acres, situated on the Rancho Sobrante de San Jacinto, in the Pinacate Mining District, 6 miles northwest of Perris; elevation 2200 ft.; owner, Ida-Leona Mining & Milling Co., H. L. Nelson, president and manager, Perris, California.

There are two systems of veins occurring in granite. The most important veins are the Gavalan and Ida-Leona which are roughly parallel, about 400 ft. apart. The Gavalan vein strikes N. 65° W., dips 30° S. Width is 12 in. to 2 ft. It is developed by a shaft sunk on the vein to a depth of 485 ft. (workings caved). The Ida-Leona vein strikes N. 65° W. and dips 60° to 65° S., width 12 in. to 4 ft. and is 400 ft. south of the Gavalan vein. About 500 ft. east of Ida-Leona shaft is a vein which strikes N. 15° W. and dips 40° W. Width is 2 ft. This vein intersects both the Gavalan and Ida-Leona veins. Present development work is confined to the Ida-Leona vein. A 2-compartment shaft is sunk on this vein to a depth of 350 ft., with drifts east and west of shaft on the following levels: 100, 150, 250 and 300-ft.

On the 100-ft. level drift 200 ft. E. and 200 ft. W.

On the 150-ft. level drift 115 ft. E.

On the 250-ft. level drift 100 ft. E. and 100 ft. W.

On the 300-ft. level drift 100 ft. E.

Ore shoot developed is 75 ft. to 100 ft. in length, with an average width of 2 ft. Quartz shows free gold associated with pyrite and galena.

Ore mined from stopes is reported to carry from $25 to $50 per ton in gold. Power plant consists of 150-h.p. diesel direct-connected with generator; 25-h.p. electric-driven hoist; 300-cu. ft. C. P. compressor. Mine run of ore is hoisted in one-ton skip to 135-ton coarse-ore bin. Ore is trammed from coarse-ore bin to small ore pocket to 6 by 8-in. jaw crusher, by bucket elevator to fine-ore bin with a capacity of 35 tons; from fine-ore bin by belt feeder to No. 43 Marcy ball mill 3 by 4 ft. in closed circuit, with duplex Dorr classifier; ground to 40-mesh. Discharge end of ball mill is equipped with Hardinge amalgamator in which 80% of coarse gold is recovered; overflow from classifier to amalgamation plate 5 ft. long by 4 ft. wide; then pulp to Diester table. Mill has a capacity of 30 tons per 24

hours. Mill is driven by 75-h.p. Holt gas engine. Production to date is reported to be $50,000. Fifteen men are employed.

Bibl.: State Mineralogist's Reports XI, pp. 334-337; XIII, p. 311; XV, p. 528; XXV, p. 478; XXX, p. 321; XXXI, pp. 508-509.

Mission Gold Mines (Huff-Lane Mines). The property comprises 7 claims and 2 mill sites, known as the Lone Star Group, situated in T. 2 S., R. 12 E., S. B. M., in the Pinto Basin Mining District, 42 miles northeast of Mecca, a station on the Southern Pacific Railroad; elevation 1200 to 1530 ft.; owner, E. C. Huff, Los Angeles; under lease and bond to Mission Gold Mines, Inc., C. H. Henderson, president, San Diego, Calif.; T. J. Foulkes, secretary; T. J. Aike, manager, Mecca, Calif.

The vein strikes N.-S. and dips 80° E. Width is 2 ft. to 4 ft., in granite. Development consists of shaft sunk on the vein to a depth of 600 ft. On the 122-ft. level, there is a drift 533 ft. N. and 191 ft. S. At 388 ft. north of shaft, there is a raise on the vein to the surface a distance of 120 ft. Ore shoot developed was 60 ft. in length, width 2 ft. Two hundred and sixty tons of ore milled from this stope are reported to have an average value of $25 per ton in gold.

On the 400-ft. level, drift N. 100 ft. and S. 120 ft.

On the 600-ft. level, drift N. 325 ft. and S. 100 ft.

Ore shoot developed north of shaft is 200 ft. in length; average width 2 ft. Four shipments of ore from this ore shoot to the Gold Crown Mining Company's mill are reported to average $43 per ton in gold.

Mine equipment consists of 6 h.p. gas-driven hoist and gardener-Denver compressor driven by automobile engine. Four men are employed.

Bibl.: State Mineralogist's Report XXV, pp. 481-482.

Red Cloud Mine. It comprises 3 patented claims, known as Great Western, White Wings and Red Head, totaling 60 acres, situated in the Chuckawalla Mountains, in Sec. 5, T. 7 S., R. 15 E., S. B. M., about 9 miles south of Desert Center and 48 miles southeast of Indio; elevation 2000 ft.; owner, J. D. Huston, 237 South Irving Blvd., Los Angeles.

The property was operated by the Red Cloud Mining Co., J. M. Huston, secretary, from 1898 to 1900, during which time the White Wings shaft was sunk on the vein to a depth of 267 ft. and the Great Western shaft to a depth of 480 ft. On the Red Head Claim, a tunnel was driven on the vein a distance of 250 ft. Ore hauled to Corn Springs and milled is reported to have had an average value of $12 per ton in gold. The property was idle until November, 1931, when it was taken under lease and bond by Charles V. Craig and associates, of Los Angeles, who installed a small mill and mined ore from the Red Head tunnel. Ore mined is reported to average $20 per ton in gold. Concentrates shipped to U. S. Smelting Company's smelter at Midvale, Utah, had an average value of $100 per ton in gold. Operations were suspended in 1933.

In 1934 the *S. & W. Mining Co.*, B. F. Schmidt, president and manager, secured an option on the property and operated until December 1, 1936. This company sank an incline shaft on the Red Head Claim to a depth of 200 ft. In this development work they encountered high-grade shoot on the footwall of the vein. It is stated the company had a production of $30,000 in bullion and concentrates shipped. The concentrates produced are stated to have carried from 20 oz. to 26 oz. in gold per ton. In January, 1937, the property was under lease to Cecil H. Smith, who operated the property until June, 1937. He shipped 300 tons of ore stated to have averaged 1.43 oz. per ton in gold. In January, 1938, the property was under option to Frank Ahlberg and associates, of Los Angeles, who operated until September, 1939, during which time, a 25-ton amalgamation and cyanide plant was installed on the property. They also sank the Red Head shaft to a depth of 300 ft. In October, 1939, the property was taken over under lease by *Super Products, Inc.,* Mark F. Jones, president; C. C. Chapman Bldg., Los Angeles.

The Red Cloud vein occurs on contact of gneissoid granite and porphyry. The hanging wall is granite and porphyry and the footwall is gneissoid granite. The vein strikes N. 20° W. and dips 60° E.; width 6 ft. to 15 ft. It can be followed along its outcrop for a distance of 4500 ft. The vein quartz is mineralized with free gold associated with pyrite. Development consists of 3 shafts and a number of tunnels.

Great Western shaft is sunk on the vein to a depth of 480 ft., with levels at 100, 150, 210, 250, and 350 ft. White Wings shaft is sunk on the vein to a depth of 267 ft., with levels at 100, 180, and 220 ft. About 500 ft. north of the White Wings shaft is the Red Head shaft which has been sunk on an inclination of 60° to a depth of 309 ft., with levels at 100, 200, 275 and 300 ft. All recent work has been confined to this shaft and the Red Head tunnel which is driven on the vein for a distance of 250 ft. In sinking this shaft to the 100-ft. level, a sulphide orebody was encountered on the hanging wall of vein, the vein-material being heavily mineralized with cube pyrite. This orebody is 12 ft. wide and reported to average $15 to $20 in gold per ton. From the 200-ft. level to the 300-ft. level on the footwall side of the vein, a high-grade lense of oxidized quartz was encountered which had an average value of $50 per ton in gold. The vein quartz was from 2 ft. to 4 ft. in width and the shoot developed was about 30 ft. in length. This ore shoot was cut off by a fault striking east and west between the Red Head shaft and White Wings shaft. The orebody developed in this shaft occurs between gneissoid granite footwall and a porphyry intrusion on the hanging wall. Ten men are employed.

Bibl.: State Mineralogist's Reports X, pp. 900-901; XV, p. 539.

Sunrise Mine. It comprises three groups of claims known as the Sunrise Group of 15 claims, Cortez Group of 3 claims and the Zulu Group of 11 claims, the latter claims being located in the Monte Negro District, 6 miles east of the Sunrise claims. The Sunrise claims are situated in Sec. 4 and 15, T. 2 S., R. 13 E., S. B. M., on the southeast slope of the Dale Hills, about 47 miles northeast of Mecca, a station on the Southern Pacific Railroad; elevation 1500 ft.; owner, Sunrise

Mines, Inc., J. R. Blessing, president; R. C. Hueler, secretary, 416 Electric Bldg., San Diego, Calif.; under lease and bond to *Pinto Basin Mining & Milling Co.,* J. L. Soske, president; R. C. Beller, secretary; A. J. Mayne, superintendent, 199 Fair Oaks Ave., Pasadena, Calif.

A series of parallel quartz veins in granite; strike N. 20° W., dip 70° SW.; width 2 ft. to 4 ft. Sunrise shaft is sunk to a depth of 300 ft. on an inclination of 75°, with levels at 100, 200, and 300 ft.

The present company is remodeling the mill for the purpose of doing custom work. Mill: 8-in. by 10-in. Blake crusher elevated to fine-ore bin; belt type of feeder from bin to 10-ft. Lane mill, then to Wilfley concentrator; pulp from concentrator to sump; then pumped to two 12-ft. by 12-ft. Deveraux agitators; two 10-ft. by 12-ft. Dorr thickeners; 8-ft. by 10-ft. solution tank. The mill has a capacity of 25 tons. Four men are employed.

SAN BERNARDINO COUNTY

Alvord Mine. It comprises 6 patented claims and one mill site situated in Sec. 1, 2 and 12, T. T 11 N., R. 3 E., S. B. M., in the Alvord Mountains, 6 miles northeast of Manix and 14 miles northeast of Yermo, a station of the Union Pacific Railroad; elevation 2500 ft.; owner, *Dellosso Gold Mining Co.,* F. G. Dellosso, president, Huntington

Alvord Mine & Mill, Manix, San Bernardino Co.

Park, Calif. The property was located in 1885 and operated until 1891 by the *Carter Gold Mining Co.,* of Pasadena, Calif., J. McLore, president.

The ore mined was treated in a 5-stamp mill at Camp Cady on the Mojave River. It is reported that they recovered $12.75 per ton by amalgamation with a loss of $1.25 per ton in the tailings. The total production during this period of operation was $50,000.

The property was operated from 1906 to 1910 by Alvord Gold Mining Co., of San Diego, Calif. This company installed a 6-Nisson stamp mill. From 1916 to 1920, the *Tintic Bonanza Mining Co.*, of Salt Lake City, Utah; Gidion Snyder, president, operated the property. F. G. Dellosso purchased the property in 1925 and formed the Dellosso Mining Company and patented 6 claims in 1931.

The claims are located along a broad belt of crystalline limestone. A dike of porphyritic rock cuts across this belt of limestone at an angle of about 90°. The principal mineralization occurs east of this dike. The rock is more or less schistose in character, through which at frequent intervals are intruded eruptive dikes. At the east end of the belt is an accumulation of tufa and basalt. The belt strikes E.-W., with a dip of 75° S.

The mineralized portion of this lode extends from the porphyry dike east through three full claims and disappears finally beneath the eruptive rocks. The entire lode is gold-bearing, some of the hematite and jasper rock being rich. Gold also occurs in the calcite, though usually lower grade than where accompanied with iron. Iron sulphides also are found carrying gold. The ore mined was limonite and jasper, showing some copper stains.

Development on Royal claim consists of glory hole 150 ft. in length and 140 ft. wide. This orebody dips 70° S. The glory hole is 200 ft. in elevation above lower tunnel and 100 ft. above upper tunnel. The upper tunnel is driven east 500 ft. on fissure in limestone. Orebody developed on this tunnel level was 100 ft. in length and 6 ft. to 12 ft. in width; stoped from tunnel level to 40 ft. of surface outcrop. The lower tunnel is driven east 550 ft. in the foot wall limestone. At 100 ft. east of the portal, a crosscut was driven south 100 ft. along contact of granite and limestone. At 150 ft. east of portal, intersected orebody exposed in upper tunnel.

Equipment consists of C.P. compressor driven by 15-h.p. Fairbanks-Morse gas engine. Mill equipment consists of 9-in. by 15-in. Blake type crusher; 6-Nisson stamps; amalgamation plates; and cyanide tanks.

Water is secured from well 500 ft. deep, with a capacity of 5000 gal. per 24 hr., 1½ miles southwest of mine. Two men are employed.

Bibl.: State Mineralogist's Reports VIII, p. 499; XI, p. 359; XIII, p. 319; XXVII, p. 281.

American Mine. It comprises 4 patented claims situated in Sec. 19, T. 4 N., R. 11 E., S. B. M., on the north slope of the Sheep Hole Mountains, 10 miles south of Amboy, a station on the Santa Fe Railroad; elevation 3600 ft.; owner, Marcus Pluth Estate, Daggett, Calif.; under lease and bond to American Mines, Inc., F. H. Merrill, president and manager; George Nilsson, secretary; Paul E. Fuller, superintendent, 908 Richfield Bldg., Los Angeles.

The country rock is rhyolite and andesite. Mineralization occurs in fine-grained rhyolitic porphyry dike. The ore occurs in fractures and seams in the rhyolite, the gold occurring free and associated with hematite; also small amounts of arsenapyrite and chalcopyrite. The orebody strikes E.-W., dips 25° N. and is from 60 ft to 150 ft. in width and about 600 ft. in length along the strike.

Development consists of a tunnel driven S. 30° E., 400 ft., then drift northeast 60 ft. to north-south fault, with drift north along fault 100 ft. At 300 ft. from portal, the tunnel intersects shaft sunk on orebody from surface. The shaft is 120 ft. in depth. There is a drift driven southwest 260 ft. from shaft. All workings on tunnel level are in trachyte. Upper tunnel is driven south 200 ft. and 150 ft. from portal, drift west 150 ft. to shaft.

Mine equipment consists of 120-h.p. Fairbanks-Morse diesel engine and Ingersoll-Rand compressor. Mill equipment consists of crusher, rolls, rod mill and sand-leaching cyanide plant, with a capacity of 50 tons. Twelve men are employed.

Atolia Mining Co. (tungsten). This property, consisting of some 60 patented claims, is situated 3 miles southeast of Randsburg; elevation 3200 ft.; owners, Atolia Mining Co., L. Wernecke, president; L. E. Putnam, superintendent; offices, 1022 Crocker Bldg., San Francisco.

A new gravity concentration and flotation plant was installed on the property in 1938, with a capacity of 300 tons per day. They are treating tailings from former mill and ore from leasers working on company's claims. Forty-five men are employed.

Bibl.: State Mineralogist's Reports XV, pp. 830-839; XVII, pp. 370-372; XX, pp. 96-97; XXVII, pp. 365-366; Bull. 95, pp. 70-78 and 125-128.

Atolia Rand Placers (gold and tungsten). The property comprises 600 acres situated in the Atolia Mining District, in Sec. 19-30, T. 30 S., R. 41 E., M. D. M., one mile southwest of Atolia; owner, Atolia Rand Placers, Inc., and *Molybdenum Corp. of America*, Dr. G. W. Sargent, president; Marx Hirsch, vice president; T. J. Crawford, secretary; M. C. Whitaker, consulting engineer, New York City. The property is under lease to H. H. Morse and C. E. Irwin, Atolia, Calif.

In 1934, the Molybdenum Corp. of America financed the building of a concentration plant having a capacity of 1500 cu. yd. per 24 hours. This new plant started operations October, 1934, and was operated until December, 1936, when operations were suspended. In 1938, H. H. Morse secured a lease on the property, operating the 100-ton concentration plant for the recovery of gold and scheelite; also operated the plant as a custom mill for gold and tungsten ores of the district. They are treating about 80 cu. yd. per day of gravel. Thirty-six men are employed.

The gravel deposit is erosion material from the Rand Mountains, washed down and deposited in narrow gulches. In the alluvium, through which there are several narrow channels, gravel has been deposited. This action has been intermittent resulting in ''layers'' which may be separated by a false bedrock of caliche. The general course of the channels is northwest-southeast. The area that has been tested with test holes is about 3 miles in length by one mile in width. While these are concentrations on bedrock (quartz-monzonite), values are said to be disseminated throughout the alluvium, thickness of which varies from 8 ft. to 30 ft. The average gold content is said to be 70¢ per

cu. yd. In addition to the gold it is estimated that the deposit will yield 2 lb. to 10 lb. of scheelite per yard.

Mill: The gravel was transported to mill by two 110-h.p. caterpillar tractors which hauled two 10-cu. yd. LeTourneau scrapers to 350-cu. yd. capacity hopper, equipped with 5-in. spaced R.R. iron grizzly. From hopper 5-in. material is fed by automatic feeder to 24-in. belt conveyor, 139-ft. centers to 28-cu. yd. circular, steel hopper. From hopper gravel goes to scalping trommel (5 ft. by 15 ft.) where it is screened to minus 2-in. size and to ⅝-in. size; oversize from trommel to 3 Hartz jiggs. The minus 2-in. goes over impact screens where it is screened to 16 mesh; plus 16-mesh material to 3 Joplin jiggs, while minus 16-mesh size goes to three 36-in. Ainley bowl separators where the gold is recovered; the Hutch product from Joplin jiggs to 3 Wilfley tables. The concentrates recovered on jiggs and tables carries 64 per cent WO_3; overflow from tables to sump tank; then pumped to 30-ft. in diameter, 8-ft. high Dorr thickener. From 1000 tons of crude material treated, they recover one ton of scheelite concentrates in 24 hr. Plant is driven by 350-h.p. Fairbanks-Morse diesel engine, direct-connected with Westinghouse generator. All equipment is driven by individual motors.

Water to operate plant is pumped from Cuddeback Lake, a distance of 8 miles, through 4-in. pipeline. Seventy-five horse power is required to operate pumps. The plant is idle at present (Sept., 1939) but if market for tungsten improves, there is a chance of resuming operations, with some changes to be made in flow sheet of plant.*

Bibl.: State Mineralogist's Report XXX, p. 323.

Bagdad-Chase Mine (Pacific Mines). The property comprises 17 patented claims, totaling 340 acres. It is situated in the Stedman Mining District, 7 miles south of Ludlow; owner, John H. Hobbs, Glendora, Calif.; under lease and bond to the *D'Aix Synd.,* F. C. D'Aix, president,; Carl D'Aix, trustee; Chester A. Todd, trustee, Chicago, Ill.

The ore is deposited in an igneous breccia on a contact of monzonite and rhyolite. The brecciated material which is the result of faulting, consists of both rhyolite and monzonite fragments cemented with highly siliceous material. The strike of the mineralized zone is east and west and dips 25° to 30° N. The average width is 8 ft. to 15 ft. The ore is principally oxides of copper, with some silicate and very finely divided gold. The gangue is very siliceous and is heavily stained with iron oxides.

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* **Footnote on the Atolia Rand Placers.**

Since the above was written, information is received that the Molybdenum Corporation of America and Atolia Rand Placers, Inc., owner, has changed to *Pacific Scheelite Corp.*, controlled by the Molybdenum Corporation of America, who owns 90 per cent of the stock and Atolia Rand Placers, Inc., owns 10 per cent of the stock of this company. The concentration plant, with a capacity of 1500 cu. yd., operated from October, 1934 until 1936 when operations were suspended. It is stated that in recent months, a considerable amount of the original equipment used in the mill has been sent to other properties owned by the Molybdenum Corporation, such as tractors, original power plant and some jigs and tables.

Developments consist of vertical shaft 400 ft. deep and incline shaft 450 ft. deep sunk on an inclination of 30°, with several thousand feet of drifts and crosscuts.

The D'Aix Synd. started operations on the property in the early part of 1938 and operated until March, 1939, during which period it shipped 850 tons of ore to Magma Copper Company's smelter at Superior, Arizona. Some shipments also went to American Smelting & Refining Company's smelter at Hayden, Arizona. Ore shipped is stated to have averaged $9.80 per ton in gold, with $2.85 in silver and 0.89% in copper.

Mine equipment consists of 2-cylinder, 125-h.p. Victor diesel engine; 10-ft. by 10-ft. Sullivan compressor; 25-h.p. single drum hoist. Idle.

Bibl.: State Mineralogist's Reports XV, p. 790; XVII, pp. 341-342; XXVII, pp. 278-279.

Big Four Mine (Red Bridge). It comprises 10 claims situated in Goldstone Mining District, 34 miles north of Barstow; elevation 3500 ft.; owner, W. B. Redfield, Goldstone, California; under lease to W. A. Fritz, Long Beach, Calif.

The mineralized zone is about 1200 ft. in width and about one mile in length. The shale and schist in this zone are cut by numerous quartz stringers and veins of quartz carrying gold. The general strike of the zone is NW.-SE., with a dip of 25° NE. The sedimentary rocks are cut by diorite dikes, roughly parallel, with a N.-W. strike.

Development consists of 5 shafts 50 ft. to 125 ft. in depth and an open cut 50 ft. in length by 20 ft. in width. The vein quartz and stringers mined are reported to carry from $20 to $200 per ton in gold. A number of trenches have been made across the mineralized zone to determine the average grade of ore.

Four men are employed on development work.

Bibl.: State Mineralogist's Report XV, p. 807.

Belmont Mine. It comprises 5 claims situated in the Goldstone Mining District, 34 miles northeast of Barstow; elevation 3500 ft.; owner, Belmont Mining Co., Dr. W. W. Ramsey, president, Stockton, Calif.; under lease to W. E. Bailey and Arthur Beale, Goldstone, Calif.

Two parallel quartz veins occur in shales and schist, strike N. 60° W. and dip 25° NE.; width 12 in. to 3 ft. The main shaft is sunk on the footwall vein to a depth of 400 ft., with levels at 100, 160, 230, 330 ft. and about 1000 ft. of drifts and crosscuts. Ore mined is said to carry from $8 to $20 per ton in gold.

Mine equipment consists of 25-h.p hoist, Chicago pneumatic compressor and blacksmith shop. They recently installed a 25-ton amalgamation and concentration plant.

Mill has a capacity of 25 tons; amalgamation and flotation; crusher, ball mill, Dorr classifier, amalgamation plates, Groch flotation cell.

Mill run of ore is stated to average $14 per ton in gold. Six men employed on development work.

Bibl.: State Mineralogist's Reports XX, pp. 46-47; XXVII, pp. 287-288.

Big Horn Mine (Mabel-Contention). It comprises 18 claims situated on the east slope of the Providence Mountains, 23 miles west of Essex; elevation 3750 ft.; owner, Big Horn Exploration Co., Watsonville, Calif., F. H. Wagenheim, superintendent, Essex, Calif.

The formation is principally quartz-monzonite, diorite, quartzite and andesite. A series of parallel, intrusive dikes of andesite cut quartz-monzonite. The dikes have a north and south trend. The quartz veins occur on both walls of these dikes. The veins vary in width from a few inches to 4 ft.; strike N. 20° E. and dip 40° to 75° W. The ore is siliceous in character and contains values in gold, silver and copper.

Development: The principal development work has been confined to the Contention and Mabel claims. On the Contention Claim a 3-compartment; vertical shaft has been sunk to a depth of 325 ft.. with levels at 160 ft. and 300 ft. On the 160-ft. level, there is a drift south 440 ft. to Subway shaft on Subway vein. The Subway vein is west of the andesite dike; strike N. 20° E., dip 65° W.; width 8 in. to 12 in. Vein quartz is mineralized with pyrite and chalcopyrite, with values in gold. About 68 ft. south of shaft, cut E-W. vein; dip 50° S.; width 10 ft. On 300-ft. level, there is a drift south 110 ft. to east-west vein, and crosscut from shaft is driven northeast 110 ft., with about 100 ft. additional to drive to intersect Contention vein.

On the Mabel Claim a shaft has been sunk on the vein to a depth of 140 ft., with 80 ft. of drifts on 140-ft. level. Width of vein is 4 ft. At a depth of 40 ft. from collar of shaft, they encountered sulphide ore.

Equipment: Power plant consists of 240-h.p., 4-cylinder, Fairbanks-Morse diesel engine, direct connected, with 200 K. V. A. generator; Imperial Type No. 10 Ingersoll-Rand compressor, capacity 550 cu. ft., driven by 100-h.p. motor; two 55,000-gal. tanks for water storage; one 30,000-gal. tank for oil storage.

Mine equipment consists of 80-ft. headframe, with ore bins; 25-h.p. hoist; complete machine shop. Four men are employed.

Bibl: State Mineralogist's Reports XV, p. 801; XVII, p. 349; XX, pp. 196-198; XXVII, pp. 303-304.

Blue Eagle Mine. It comprises 8 claims, situated on the north slope of the Old Woman Mountains, in Danby Mining District, in Sec. 19, T. 6 N., R. 17 E., S. B. M., 6½ miles southeast of Danby, a station on the Santa Fe Railroad; elevation 2900 ft.; owners, Nicholas C. Aldo and W. Baldwin, Hollywood, Calif.

Three parallel veins occur in granite about 200 ft. apart, strike N. 30° W., 80° E.; width 12 in. to 2 ft. Vein quartz carries free gold associated with iron pyrite, arsenopyrite, galena and sphalerite.

Development consists of a shaft sunk on West vein to a depth of 160 ft. About 1000 ft. north of this shaft, another shaft has been sunk on vein to a depth of 50 ft. Selected ore shipped to Burton Bros., Inc., at Rosamond, California., is reported to have had an essay value of $50 per ton. At present ore is being mined from Florence vein from opencuts along outcrop for a distance of 500 ft. These workings are about 1000 ft. south of No. 1 shaft.

Equipment consists of 6-h.p. hoist and portable Ingersoll-Rand Compressor, capacity 260 cu. ft. Ore is hauled by truck to mill, with

a capacity of 20 tons per 24 hr.; 6-in. by 8-in. crusher, to rolls and ground to $\frac{1}{8}$-in. size; then elevated to ore bin; ore from bin to Herman ball mill where it is ground to 40 mesh; then over amalgamation plates (4 ft. wide by 8 ft. long); overflow from plates to Plato concentrator. Mill is driven by 40-h.p. Holt gas engine. Concentrates produced are reported to carry $200 to $300 per ton in gold. Water for mill is pumped from No. 1 shaft to storage tank, then flows by gravity through 2-in. pipeline 900 ft. long to mill.

Bonanza Dome & Beacon Group of Mines (tungsten). In the Bonanza Dome Group there are 6 claims and in the Beacon Group 7 claims, situated in the Mirage Lake Mining District, in Sec. 6 and 32, T. 7 N., R. 6 W., S. B. M., 14 miles west of Adelanto and 23 miles northwest of Victorville; owners, Nicholas Baxter and Norris Williams, San Bernardino, Calif.; elevation 2500 to 3000 ft.

Scheelite is in contact with metamorphic rocks along contact of granite and limestone. The scheelite is irregularly associated with epidote in lime-silicate rocks. The general strike of the mineralized zone is N.-S., dip 60° W. It varies from 50 ft. to 90 ft. in width. Opencuts expose three lime-silicate veins from 8 ft. to 20 ft. in width. Ore extracted from opencuts and shallow shafts is reported to carry 0.5% WO_3. Three men are employed on development work.

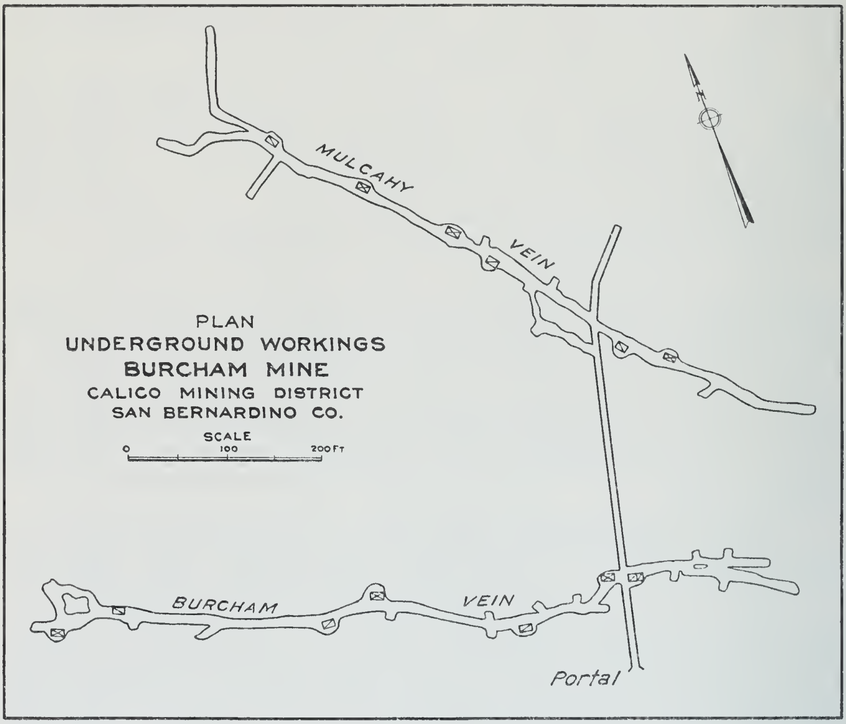
Burcham Mine (Total Wreck). The property comprises 21 unpatented mining claims, consisting of 415 acres, is located in the Calico Mining District, on the south slope of the Calico Mountains, in Sec. 16 and 21, T. 10 N., R. 1 E., S. B. M., 12 miles northeast of Barstow, 5 miles northwest of Yermo; elevation 1800 to 2850 ft.; owner, Dr. Rose L. Burcham, Alhambra, Calif. The property is under lease and bond to Burcham Mines, Inc., H. S. Kimball, president; I. S. Betts, secretary; Granville Moore, consulting engineer and manager, Los Angeles, Calif.

The rocks of this and the adjoining Calico District area, comprise a closely-related series of Tertiary flows, with associated tuffs, conglomerates or breccia. They are cut by numerous dikes and irregular intrusions of rhyolite and other rocks. The oldest and most important ore-bearing formation is an interbedded series of rhyolite flows, including breccias, massive tuffs, porphyritic flows, banded flows and water-laid deposits of several kinds of volcanic debris, including well-laminated silts. Faulting is widespread throughout the entire district. However, only two of the fractures are exposed to any extent by the underground workings in the Burcham Mine, limited to some 800 ft. along the strike of each of the two fractures. All orebodies developed on the property are localized along these two faults and their branches. The development has been confined mainly to two veins within the two fractures, known as the Burcham vein and the Mulcahy vein.

The Burcham vein strikes N. 70° W. and dips 35° to 65° S.; width 3 ft. to 7 ft. The valuable minerals in this vein are gold, silver and lead. The gold is finely divided and disseminated throughout the quartz, with iron present as hematite and limonite. Lead occurs as lead carbonate, with occasional bunches of galena. Silver occurs as silver chloride. The Mulcahy vein is 300 ft. to 500 ft. north of the Burcham and the principal values are in gold and silver. The Mulcahy

vein strikes N. 45° W. and dips 65° S.; width 4 ft. to 30 ft., with high-grade streak on footwall; width 26 in., with mineralization extending into hanging wall for a width of 15 ft. to 30 ft. Ore shoot developed on this vein is 600 ft. long, average width 20 ft. and reported to have an average value of $6.50 per ton in gold and silver.

Development consists of cross-cut tunnel N. 15° E., 512 ft. in length. At 104 ft. from portal, intersected the Burcham vein, with drift on the vein 200 ft. southeast and 640 ft. northwest. The Burcham vein where intersected by cross-cut tunnel, had a total width of 90 ft. A shaft, the collar of which is located at the surface directly above the southeastern side of the intersection of the vein by cross-cut tunnel,



is sunk to a depth of 60 ft. below tunnel level, all in ore. Total depth of shaft is 150 ft. Two raises have been put up to the surface on the Burcham vein. One is located northwest of cross-cut, the other near face of northwest drift.

Three winzes have been put down on the Burcham vein to a depth of 100 ft. below tunnel level about 200 ft. apart in the northwest drift and cross-cuts are being driven to determine width of orebody. In this development work bunches of sulphide ore have been encountered, being galena associated with sphalerite. The Mulcahy vein was intersected by cross-cut tunnel at 410 ft. north of tunnel, with drift northwest on the vein 500 ft. and southeast 240 ft. Where cross-cut tunnel cut the vein, the width of the vein is 30 ft. The high-grade streak mined on this vein has a width of 26 in. to 30 in.,

reported to average $15 per ton. Total amount of underground workings is about 10,000 ft.

Equipment consists of 2 compressors, one of 360-cu. ft. capacity, driven by 75-h.p. motor, the other of 160-cu. ft. capacity. Electric power is secured from Southern Sierras Power Co. Water is secured from well on the property below mine, depth of well being 250 ft. The water is pumped with Triplex pump through $2\frac{1}{2}$-in. pipeline to storage tank; lift 218 ft. Twenty-five men are employed on development work.

Bibl.: State Mineralogist's Reports XI, p. 343; XVII, p. 351; XXVII, pp. 358-359.

Carlyle Mine. The property comprises 4 patented claims and 4 claims held by location, located in Sec. 11, T. 1 S., R. 12 E., S. B. M., in the Dale Mining District, on the northeast slope of the Dale Mountains, 7 miles northeast of New Dale and 23 miles southeast of Twenty-nine Palms; elevation 2500 to 3000 ft.; owner, Carlyle Mining Corp., Geo. C. Dorman, president; A. E. Cates, secretary, 202 Quinby Bldg., Los Angeles. The property is under lease and bond to *Camco Mining Co.*, R. M. Campbell, president and manager, Twenty-nine Palms, Calif.

The Carlyle Mining Corp. operated the property from June, 1936, to March, 1938, during which period it mined and milled 13,256 tons of ore, recovering $124,000. Camco Mining Co. started operations April 15, 1939.

The vein occurs in a fault fissure, having a diorite footwall, with granodiorite hanging wall. The vein strikes N. 15° E. and dips 75° W.; width 6 ft. to 12 ft. Gold occurs in a fine state associated with silver chloride, lead carbonate and galena. Silver minerals in the ore are pyrargyrite, polybasite and stephanite. Lead minerals are galena, anglesite and cerrusite.

Development consists of lower tunnel driven south 1500 ft. in quartz-diorite. No ore developed and the tunnel is driven parallel to vein developed in upper workings. About 330 ft. in elevation above lower tunnel, the main working tunnel is driven south 1200 ft. on the vein. Five ore shoots were developed on this level. These ore shoots are 50 ft. to 150 ft. in length, with 200 ft. of backs. First ore shoot was intersected 600 ft. south of portal of tunnel. The ore shoot is 100 ft. in length, with average width of 6 ft.; stoped to surface. At 680 ft. south of portal, a winze is sunk on the vein to a depth of 330 ft. At 580 ft. south of portal, there is a raise put up on vein to the surface, a distance of 200 ft.; at 480 ft., raise up 150 ft. to surface. At 680 ft. from portal of tunnel winze workings below tunnel level. There are levels at 30 ft. and 80 ft. On the 30-ft. level drift 200 ft. on vein; on 80-ft. level drift 350 ft. Ore shoot developed on these levels is 60 ft. in length, 6 ft. in width, with high-grade silver ore on footwall and gold ore on hanging wall. The gold ore is reported to average $12 per ton.

Mine equipment consists of Chicago Pneumatic Hot Head compressor with a capacity of 500 cu. ft., located in mill. Air line from mill to mine consists of 2-in. pipeline 3000 ft. in length; blacksmith shop and air drills.

Mill: Mine run of ore from upper tunnel is trammed in one-ton cars to ore bin with a capacity of 70 tons. From this ore bin, the ore is transported by aerial tram 2680 ft. in length, equipped with 2 buckets, each having a capacity of 1500 lb. The tram is driven by 30-h.p. motor. Ore is dumped into coarse-ore bin with a capacity of 60 tons. Ore from bin goes to No. 5 Kennedy gyratory crusher where crushed to one-in. size. From gyratory crusher ore is conveyed by 14-in. belt conveyor to 80-ton fine-ore bin. Ore goes from fine-ore bin by 16-in. belt feeder to 5½ ft. by 6 ft. Traylor ball mill, in closed circuit with 5-ft. by 22-ft. Dorr duplex classifier, with Pan American jig between ball mill discharge and classifier to recover coarse gold. Ore is ground to minus 100 mesh; overflow from Dorr classifier to 6-cell Kraut rougher cells; the concentrates from rougher cells to 2-cell Kraut cleaner cells; the tailings from 6-rougher cells to 2 Kraut scavenger cells; concentrates from cleaner cells to 3-ft. by 4-ft. Oliver filter. The concentrates recovered on scavenger cells are returned to rougher cells. Tailings from scavenger cells to Deister table cut a concentrate from table carrying iron and lead which carries $40 to $60 in gold and silver. This concentrate is shipped separately. Flotation concentrate from cleaner cells is reported to carry $800 to $1000 per ton. Ratio of concentration is 200 to 1. Heads carry from $10 to $20 per ton in gold, with $3 to $6 per ton in silver. Tailings from mill flow by launder to 8-ft. by 20-ft. Dorr thickener. Power to drive mill consists of 225-h.p. Fairbanks-Morse 3-cylinder diesel, direct connected to 150 K.V.A. General Electric generator. Water supply is from well 135 ft. deep; 8-in. casing. Water is pumped by Ingersoll-Rand pump, driven by 30-h.p. motor. Three-stage plunger booster pump lifts water through 3-in. pipeline, two miles to storage tank above mill, with a capacity of 30,000 gal. The lift to storage tank is 900 ft.

Reported recovery made in treatment of the ore is 80% to 90% of the gold and 75% of silver.

Analysis of concentrates shipped is as follows:

Gold	52.15 oz.
Silver	844.79 oz.
Lead	23.55%
Copper	1.12%
Insol.	29.40%
Iron	15.80%
Arsenic	0.23%
Antimony	0.67%
Bismuth	0.03%
Calcium oxide	1.80%

Gross value of concentrates $2411.33 per ton. Twelve men are employed on development work and in the mill.

Coarse Gold Mine. It comprises 5 claims located in the Arrow Mining District on the east slope of the Providence Mountains, 22 miles west of Essex, a station on the Santa Fe Railroad; elevation 3200 ft.; owner, Coarse Gold Mining Co., John Riddle and W. Stephanson, Fenner, Calif.

The vein occurs in granite, strikes N. 30° E. and dips 70° E.; width 2 ft. Development consists of shaft 75 ft. deep sunk on the vein, with drifts north and south on 70-ft. level for a distance of 100 ft.

Several shipments of ore made are reported to have averaged $26 per ton in gold. Equipment consists of 6-h.p. gas engine hoist and portable compressor with a capacity of 150-cu. ft. Idle.

Cumberland Mine. It comprises 7 claims, located in the Ord Mountain Mining District, on the south slope of the Ord Mountains, in Sec. 25 and 26, T. 6 N., R. 2 E., S. B. M., 17 miles northeast of Lucerne and 35 miles east of Victorville; elevation 3500 ft.; owners, Harry Fredericks and Hugh Connell, Alhambra, Calif.

Discovery of ore on these claims was made in 1900 by Samuel Clark, who hauled the ore to Old Woman Springs for treatment in an arrastre.

A quartz vein occurs in granite; strikes N.-S. and dips 85° W.; width 18 in. to 3 ft. It is developed by shafts from 50 ft. to 135 ft. On the Cumberland Claim, the north shaft is 75 ft. in depth. About 175 ft. south of this shaft is a shaft sunk on the vein to a depth of 135 ft. On the 135-ft. level of the south shaft, there is a drift 100 ft. N. and 50 ft. S. The vein quartz developed in these workings is mineralized with hematite, pyrite, marcasite and chalcopyrite. Two men are employed on development work.

Dale Dry Lake (sodium sulphate). The property comprises 1400 acres located on Dale Dry Lake, in Sec. 20, 21, 22, 23, 25, 26, 27, 28, 29, 33, 34 and 35, T. 1 N., R. 12 E., S. B. M., 18 miles east of Twenty-nine Palms; elevation 1181 ft.; owner, *Chemical Mines Co.*, Irving E. Bush, president, 1204 W. 31 St., Los Angeles. The property is under option to *Dale Chemical Corp.*, J. F. Foran, president; Lee Richardson, secretary and manager, 307 W. 8th St., Los Angeles.

The brines of this dry lake contain sodium sulphate and other salts. The company is installing a plant for the recovery of sodium salts. Six men are employed.

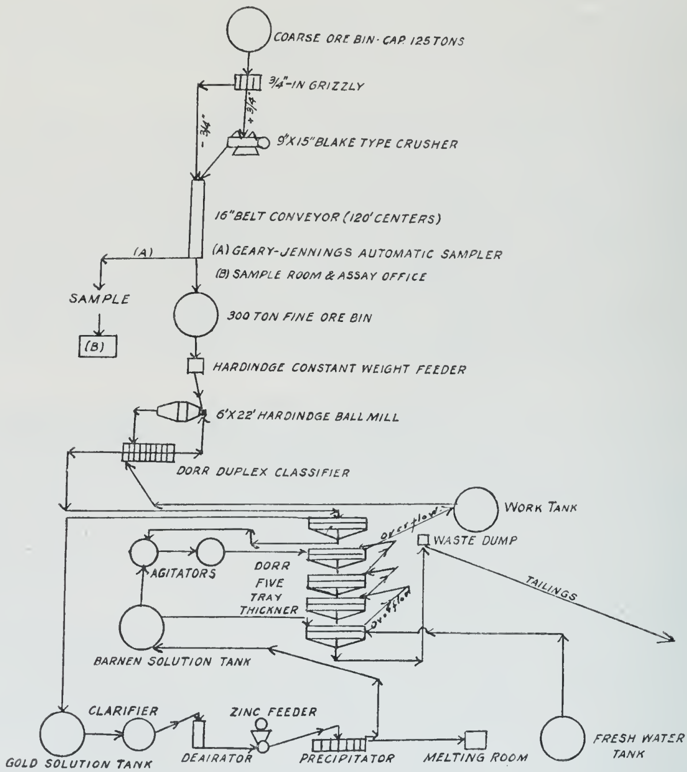
Gold Crown Mine (Nightingale & Supply). The property comprises 5 claims in the Nightingale Group and 9 patented claims in the Supply Group, situated in the Dale Mining District, on the northwest slope of the Dale Mountains, in Sec. 35, T. 1 S., R. 11 E., S. B. M., 2 miles east of New Dale and 20 miles southeast of Twenty-nine Palms; elevation 2350 ft.; owner, Gold Crown Mining Co., Geo. Novell, president and general manager; Edward Novell, superintendent; offices, Petroleum Securities Bldg., Los Angeles.

The Nightingale-Supply vein occurs in andesitic porphyry, strike N.-S., dip 70 to 85° E. and width 4 ft. to 12 ft. The Supply shaft was sunk on the Supply vein to a depth of 1250 ft., with levels at 100-ft. interval and over 5000 ft. of underground workings. Production from the Supply Mine is said to have been over $500,000. Present work is confined to the Nightingale Group. The Nightingale shaft is situated 3600 ft. north of the Supply shaft and is on the same vein. The Nightingale shaft has been sunk on an inclination of 85° to a depth of 675 ft. The vein developed is 9 ft. to 12 ft. in width. The ore shoot developed is 250 ft. in length, with an average width of 9 ft. Ore mined is stated to average $12 per ton in gold. Levels are at 75-ft. intervals. On the 375-ft. level, 212 ft. south of Main shaft, a winze is sunk to the 750-ft. level, with levels at 450, 525, 600, 675

and 750 ft. On 525-ft. level drift south 625 ft.; on 600-ft. level drift south 600 ft.; on 675-ft. level drift south 600 ft. and north 220 ft. A winze is sunk to 825-ft. level; on 750-ft. level drift south 265 ft. Total underground workings are about 6000 ft. The main working shaft is a 2-compartment shaft with a 60-ft. steel headframe.

Ore is hoisted in one-ton skip by 25-h.p. electric hoist and dumped direct into steel ore bin, with a capacity of 125 tons. From ore bin, ore is fed by belt type of feeder to ½-in. grizzly; then oversize from grizzly to 9-in. by 15-in. Blake type of jaw crusher; ½-in. crusher product to 16-in. incline belt conveyor (120-ft. centers) to 300-ton circular steel fine ore bin. From fine-ore bin, ore goes to Hardinge

FLOW SHEET
OF
FIFTY TON CYANIDE PLANT
GOLD CROWN MINING COMPANY
LTD.



Constant Weight Feeder to 6-ft. by 22-ft. Hardinge ball-mill driven by 75-h.p. motor. The mill is in closed circuit with Dorr duplex classifier. Ore is ground in cyanide solution so 95% will pass through 100-mesh screen; overflow from classifier to 5-tray Dorr thickener. From primary thickener, the thickened pulp goes to 2 Devereaux agitators. Gold solution overflows from top tray No. 1 and flows by launder to gold solution tank; the thickened pulp from Dorr thick-

ener to No. 1 agitator, then into No. 2 agitator, where solution is further thickened. From No. 2 agitator, the solution is pumped to No. 2 tray in Dorr thickener. Here the pulp is further thickened and forced downward to No. 3 tray, then No. 4 and No. 5 trays and on out through waste pump to tailings. No. 2 tray overflow passes to work tank, then back to the classifier. The overflow from No. 4, 5 and 3 trays is pumped upward to be passed from No. 2 tray into work tank, then back to classifier. Solution from gold solution tank goes to clarifier where lead nitrate is added, then to deaerator to Merrill-Crowe precipitation process. The recovery is reported to be 95%, with loss in tailings from 80¢ to $1.00. (See flow sheet.)

Gold Crown Mine and 50-ton Cyanide Mill, Dale Dist., San Bernardino Co.

Power plant to operate mill and mine equipment consists of 300-h.p., 4-cylinder, Fairbanks-Morse diesel engine, direct connected with 170 K. V. A. generator. Seventy-five-h.p. motor drives 300-cu. ft. Ingersoll-Rand compressor. Water supply for mine and mill is secured from well 265 ft. deep, 10-in. casing. Water is pumped by Byron-Jackson submersible pump driven by 30-h.p. motor, through $3\frac{1}{2}$-in. pipeline 2 miles in length, with a lift of 1400 ft. to storage tank at mine, with a capacity of 43,000 gal. The mill is also operated as a custom plant for ore from mines in the Dale District. Thirty-five men are employed.

Bibl.: State Mineralogist's Reports XV, p. 802; XXVII, pp. 314-315.

Gold Divide Mine. It comprises 6 claims situated in the Goldstone Mining District, 8 miles east of Goldstone, 25 miles northeast of Barstow; elevation 3500 ft.; owner, John E. Frey, Barstow, Calif.

Five parallel quartz veins occur in schist between limestone. The veins strike NW. and SE. and dip 80° NE.; width 12 in. to 2 ft. A shaft is sunk on vein on contact of limestone and schist to a depth of 85 ft. The hanging wall is limestone and the footwall schist. About 350 ft. south of 85-ft. shaft, is shaft 107 ft. deep. South on parallel vein is 100-ft. shaft on 100-ft. level, drift 165 ft. on the vein. About 250 ft. east of this shaft, a cross-cut tunnel is driven east 102 ft. in schist.

Mine equipment consists of 12-h.p. hoist. Two men are employed on development.

Gold Hill Mine. The property comprises 12 claims situated in Bear Valley Mining District, in Sec. 17, T. 2 S., R. 2 E., S. B. M., 8 miles east of Pine Knott P. O., Big Bear Lake; elevation 6700 ft. to 7280 ft.; owners, Albert L. Rose and Geo. W. Tartar, Big Bear Lake, Calif. Under option to Leo Morrison, Inc., Leo Morrison, president; V. M. Stephenson, consulting engineer; A. L. Rose, superintendent, Hollywood, Calif.

A series of parallel veins in quartzite strikes E.W. and dip 35° to 45° N.; width 2 ft. to 10 ft. Mineralization occurs along bedding planes of quartzite, near contact of diabase and monzonite. The principal development is on Gold Hill No. 1 and on Gold Hill No. 3 claims. On Gold Hill No. 1 Claim, a crosscut tunnel is driven N. 20° E. 550 ft. This tunnel is in monzonite for a distance of 175 ft., then in quartzite for the remaining distance. On No. 2 Gold Hill Claim, 350 ft. in elevation above crosscut tunnel, there is an opencut on mineralized showing along bedding planes of quartzite near contact of diabase. Opencut is 20 ft. in length by 10 ft. in depth.

On Gold Hill No. 3 Claim, vein in quartzite strikes E. and W. and dips 35° N.; width 8 ft. to 10 ft. Incline shaft sunk on bedding plane on footwall of vein to a depth of 25 ft., developing 3 ft. of ore. Thirty feet north of incline shaft, there is a vertical shaft 50 ft. deep south of vein, with crosscut to vein. Ore extracted from these workings amounting to about 10 tons, is reported to have an average value of $20 per ton in gold. There is another shaft south of these workings 20 ft. deep sunk on contact of diabase and quartzite.

On Gold Hill No. 7 Claim, a crosscut tunnel has been driven southeast 30 ft. cutting a cross fracture in quartzite which strikes N. 20° E. and dips 45° W., with a drift south on fissure 30 ft. On Junction claims north of the above-mentioned workings are two shafts sunk on contact of diabase and quartzite to depths of 75 ft. Ore is reported to be low grade.

Present work is confined to development work on opencut above crosscut tunnel on No. 2 Claim and in driving crosscut tunnel to intersect bedding plane in quartzite exposed in opencut on No. 2 Claim. Ten men are employed.

Gold Mountain Mine (Lucky Baldwin). The property comprises 16 claims, 8 of which are patented and 8 surveyed for patent, situated in the San Bernardino Range, north of Baldwin Lake, in the Bear Valley Mining District, in Sec. 6, 7, 25, 31 and 35, T. 2 N., R. 1 E., S. B. M., 6 miles northeast of Big Bear Lake; elevation 7350 ft.; owner, James Hulmes, South Pasadena, Calif. The property is under option

to the Gold Mountain Mining & Development Co., Big Bear Lake P. O., Fred C. Cline, president and manager.

The vein system consists of irregular bodies of massive quartz in quartzite on contact with schist; with schist footwall and quartzite hanging wall. The strike of the orebody is N. 60° W., dip 30° to 60° S. Average width of the vein is 40 ft. The principal mineralization occurs along cross fractures in the quartzite that strike NE.-SW.

Development consists of glory hole 600 ft. in length by 40 ft. wide and 50 ft. deep. Main adit tunnel is 700 ft. in length, driven N. 60° W. 85 ft. vertically below outcrop. The ore mined from the glory hole is said to have an average of $6 per ton.

The present operator has installed a mill with a capacity of 40 tons. Ore from glory-hole level is mined, loaded in cars to coarse-ore bin with a capacity of 200 tons; ore from bin to 9-in. by 15-in. jaw crusher, then to 9-in. by 15-in. secondary jaw crusher to fine ore bin, capacity of 200 tons; from fine-ore bin by belt feeder to 4 ft. by 5 ft. Rod Mill in closed circuit with Dorr Classifier, ground to minus 40 mesh, to bowl type of amalgamator, overflow to Gibson amalgamator then to Plato table—concentrates carry $50 per ton in gold.

Water is secured from Baldwin Lake, pumped by Gould Triplex pump through 3-in. pipeline 6000 ft. in length to storage tank at mine; Gardner-Denver air compressor. Ten men are employed.

Bibl.: State Mineralogist's Report XVII, pp. 346-347; XII, p. 232; XIII, p. 322; XXVII, p. 298.

Gold Rose Mine. It comprises 6 claims situated in the Dale Mining District, adjoining the Los Angeles Group of Mines on the southwest and on the south slope of the Dale Mountains, 45 miles northeast of Mecca; elevation 1700 ft.; owners, C. A. Foletta, C. L. Allison and Dale Holmes, of San Bernardino, Calif.

Four parallel veins occur in granite. The veins strike NW.-SE. and dip 70° to 80° NE. The veins vary in width from 2 ft. to 6 ft. Developments consist of 5 shafts sunk on different veins to depths of 50 ft. to 250 ft. No. 2 Shaft on the west side of Brooklyn Wash is 235 ft. deep, sunk on an inclination of 70°. Gold Rose No. 4 Shaft is sunk on vein east of wash. The shaft has been sunk to a depth of 200 ft. on an inclination of 80°. On 100-ft. level there is a drift south on vein 200 ft.; on 200-ft. level, drift south 240 ft. On the same vein about 500 ft. south of shaft, there is a shaft 100 ft. deep and a tunnel 50 ft. in length. Vein is 6 ft. wide. Vein quartz is mineralized with gold associated with pyrite, chalcopyrite and galena.

Mine equipment consists of 12-h.p. Novo gas-driven hoist; Rix compressor driven by LeRoi gas engine; No. 6 blower. Ore from mine is dumped into bin with a capacity of 25 tons; 7 by 10-in. Blake crusher; Wheeler ball mill, driven by 40-h.p. Holt gas engine. Ore is ground in ball mill to pass 40-mesh screen; pulp from ball mill to amalgamating jig, then over amalgamation plates; to steel cone tank; overflow from cone to two 5-ft. by 8-ft. steel settling tanks. Water from final settling tank is pumped back to head of mill. Six men are employed.

Bibl.: State Mineralogist's Report XXVII, pp. 298-299.

Ivanhoe Mine. It comprises 13 claims situated in Dale Mining District, on the east slope of the Dale range of mountains, 2½ miles east of New Dale and 22 miles east of Twenty-nine Palms; elevation 3000 ft.; owner, Denny B. Pardo, San Bernardino, Calif.; under lease to Dewey Campbell, San Bernardino.

Three parallel veins known as Top Nest, Hidden Treasure and Ivanhoe, occur in andesitic porphyry. The veins strike N. 20° W. and dip 80° E. Widths of veins vary from 2 ft. to 6 ft. The vein quartz is stained with copper oxides and shows considerable hematite and some free gold associated with pyrite and chalcopyrite. The principal development is confined to the Ivanhoe vein. On this vein a shaft has been sunk to a depth of 215 ft., with levels at 75, 125 and 200 ft., with about 1000 ft. of drifts. Ore mined is being hauled to Sunrise mill for treatment.

Equipment consists of 15-h.p. gas engine hoist and compressor. Mill is at New Dale and consists of 25-ton cyanide plant. Six men are employed.

Bibl.: State Mineralogist's Report XXVII, p. 302.

Johnson Mine. It comprises 4 claims, tunnel site and mill site, situated in the Ord Mountain Mining District, on the south slope of the Ord range of mountains, in Sec. 36, T. 6 N., R. 2 E., S. B. M., 17 miles northeast of Lucerne P. O. and 40 miles east of Victorville; elevation 400 ft.; owner, R. H. Johnson, Pasadena, Calif.

The vein occurs along a fault fissure in granite, strike N. 10° E., dip 85° W.; width 12 in. to 2 ft. Development consists of a crosscut tunnel driven S. 70° E., 400 ft. to vein, with drift north 250 ft. and drift south 250 ft. Several small lenses of iron-stained quartz have been developed in the north drift.

Mine equipment consists of 12-h.p. Fairbanks-Morse gas engine which drives Ingersoll-Rand compressor, with a capacity of 75 cu. ft.; blacksmith shop and air drills. Idle.

Bibl.: State Mineralogist's Report XXVII, pp. 302-303.

Jupiter Mine. It comprises 5 claims situated in the Dale Mining District and adjoins the Carlyle Mine on the west and south, in Sec. 11, T. 1 S., R. 12 E., S. B. M., 7 miles northeast of New Dale and 23 miles southeast of Twenty-nine Palms; elevation 2500 ft.; owner, Sels Bush, Twenty-nine Palms, Calif. During 1937 the property was under option to Frank A Berger and Mathew Gilbert, Beverly Hills, Calif. During this period these parties mined 1000 tons of ore which was milled in the Carlyle mill said to have averaged $25 per ton in gold. Some ore was also shipped to the Gold Crown mill for treatment.

Two parallel veins occur in andesitic porphyry. One known as Bodsworth is 30 ft. east of Jupiter vein. The principal development work is confined to the Jupiter vein. The veins strike N. 14° E. and dip 80° W.; width 2 ft. to 8 ft. Development consists of tunnel driven south 200 ft., with several hundred feet of crosscuts and raises. Considerable development work was done on the south end of this group of claims, consisting of a shaft 200 ft. deep. A road was constructed to the south end of the property from the Supply Mine. Idle.

Bibl.: State Mineralogist's Report XXXIV, p. 15.

Long Shot Mine. The property comprises 7 claims situated in the middle portion of the Old Woman Mountains, in Sec. 30 and 32, T. 6 N., R. 17 E., S. B. M., 16 miles southeast of Danby, a station on the Santa Fe Railroad; elevation 3600 to 4900 ft.; owners, L. J. Rouchleau and Mrs. M. M. Richardson, Los Angeles; under option to Clifford Gellespie, Hollywood, Calif.

The formation is granite, with inclusions of mica and hornblende schists. The Long Shot vein occurs in granite, strikes N. 40° W. and dips 70° to 75° SW.; width 12 in. to 4 ft. The vein occurs along a well-defined fracture in the granite and can be followed along its outcrop for a distance of 6000 ft. There is also a series of parallel N. 55° E. veins that intersect the main Long Shot vein. Some of these veins have been productive.

The principal development work, however, has been confined to the Long Shot vein. At an elevation of 4000 ft., a shaft has been sunk on the vein to a depth of 70 ft. A crosscut tunnel has been driven west 40 ft. to vein; then a drift driven northwest 179 ft. intersecting shaft on the 70-ft. level. On the 50-ft. level, there is a stope 60 ft. in length stoped up to 10 ft. above 50-ft. level. The vein stoped had a width of 12 in. to 2 ft. The ore extracted is reported to have an average value of $35 per ton. The quartz is mineralized with pyrite and chalcopyrite, the gold being in the sulphides. About 160 ft. in elevation below these workings, a crosscut tunnel is being driven west to intersect the vein. At present this tunnel is 100 ft. in length and it is estimated the tunnel will have to be extended an additional 200 ft. to intersect the vein. Ore shipped from the property by former owners to International Smelting Co. and the United States Smelting & Refining Co., Salt Lake City, Utah, carried from .96 oz. to 1.57 oz. in gold per ton. The upper camp has an elevation of 3740 ft. At this point there is a 220-cu. ft. Chicago pneumatic compressor from which a 2-in. pipeline extends 900 ft. to lower crosscut tunnel. At upper crosscut tunnel, there is 80-cu. ft. compressor. Water from spring near upper camp has a flow of 1800 gallons in 8 hr. From upper tunnel there is a jig-back tramline to upper camp 1000 ft. in length. There are also a number of shallow shafts and opencuts on the main vein to depths of 20 ft. to 50 ft. On the intersecting veins are a number of shafts 50 ft. in depth and tunnel 150 ft. in length, with jig-back tramlines to lower camp. Six men are employed.

Los Flores Gold Placers. This property comprises 18 placer claims totaling 360 acres, situated in the San Bernardino range of mountains, in Sec. 31 and 32, T. 3 N., R. 4 W., S. B. M., 7 miles east of Summit, a station on the Santa Fe Railroad and 12 miles east of Cajon; elevation 3300 ft.; owner, Frank H. Hunter, Long Beach, Calif.

Gravel channel strikes E.-W. is one-quarter of a mile in width and one mile in length. Bedrock is gneissoid granite. The gravel is made up of quartz and granite boulders. There are no large boulders. Pannings taken show three to ten colors to a pan. Depth of gravel is 10 ft. to 20 ft.; reported to carry values of 30¢ to $1.00 per cubic yard. The property is developed by shallow shafts and test pits. Two men are employed.

Los Padre Mine. It comprises 8 claims situated in Dry Lake Mining District, 36 miles east of Lucerne P. O. and 55 miles southeast of Victorville; elevation 3500 ft.; owners, Los Padre Mining Co., M. C. Clemens, president; C. B. Caldwell, secretary, 540 Title Insurance Bldg., Los Angeles.

The vein strikes E.-W. and dips 80° S.; width 2 ft. to 3 ft. It occurs in gneissoid granite. Development consists of crosscut tunnel driven north 700 ft. to Padre vein, with drift east on the vein 80 ft. and 300 ft. west. An incline shaft is sunk on the vein from the surface to a depth of 150 ft., intersected the west drift 50 ft. north of lower crosscut tunnel. There is an upper tunnel driven on the vein which intersects the shaft 50 ft. below collar of shaft and a drift on the vein 200 ft. northwest. Some high-grade gold ore was recovered from the upper workings, the gold in the quartz being in wire form. The west drift in lower tunnel level developed an ore shoot 30 ft. in length with an average width of 18 in. The company sunk a well about one-half mile west of the property, developing sufficient water for camp and milling purposes. A 20-ton amalgamation and concentration plant has been installed on the property. Idle.

Louisiana Mine (Louisiana-California). The property comprises 8 claims situated in the Signal Mining District, in Sec. 15 and 22, T. 11 N., R. 18 E., S. B. M., 8 miles north of Goffs; elevation 3350 ft.; owner, *California Comstock Gold Mines, Ltd.,* M. H. Collins, president; E. S. Gable, secretary, Fox Theatre Bldg., San Bernardino, Calif. The company operated the property in 1936 and 1937. The *Universal Classifiers, Inc.,* of New Orleans, installed a 50-ton dry concentration plant on the property but recoveries were not satisfactory, causing a suspension of operations in the early part of 1937.

Two parallel veins from 4 ft. to 12 ft. in width occur in granite; strike E.-W., dip 45° N. The veins are cut by a series of diabase and andesitic porphyry dikes which strike NE. and SW. The ore carries values in gold and silver associated with galena, cerusite, chalcopyrite and vanadinite. The vanadium occurs as a coating along seams in the quartz vein in the form of cuprodescloizite. Development consists of a 2-compartment, vertical shaft 925 ft. deep, with levels at 212, 250, 300, 400, 500, 600, 700, 800 and 900 ft., with 6000 ft. of drifts and crosscuts. At the time the property was visited ore was mined from the 212 and 250-ft. levels. The West shaft located 287 ft. south of Main shaft is 130 ft. deep.

Mine equipment consists of 25-h.p. Ridgeway gas engine hoist and a portable compressor, with a capacity of 300 cu. ft. Mill equipment consists of jaw crusher, Hammer mill, double deck vibrating screens. Sizes produced were 25, 30, 40, 50, 60 and 70-mesh. Mill is driven by 40-h.p. diesel engine. Water was secured from North shaft. Thirty men were employed. Idle.

Bibl.: State Mineralogist's Report XV, pp. 850-852.

Merrick Mine (Gold Crown Group). It comprises 13 claims situated in Goldstone Mining District adjoining the Belmont Group of Mines on the east, in Sec. 35, T. 14 N., R. 1 E., S. B. M., 34 miles northeast of Barstow; elevation 3200 ft.; owner, Michell Merrick, Goldstone, Calif.

A series of stringers and quartz veins occurs in a belt of schist about 500 ft. in width, strike NW.-SE. and dip 30° to 40° NE. On the east edge of this belt of schist is a diorite intrusion. Development consists of a crosscut tunnel driven southwest 124 ft., with 30 ft. of backs. This tunnel intersected a number of stringers and quartz veins; widths 2 in. to 12 in. South of this tunnel on ridge above the tunnel, a number of opencuts and shallow shafts were sunk on different veins of quartz. Thirty-three tons of ore were mined recently and shipped to Burton Bros., Inc., Rosamond, Calif., valued at $1370. About 500 ft. northwest of these workings, a shaft was sunk by Beale & Baily to a depth of 100 ft. on an inclination of 40°. The vein strikes NE.-SW. and dips 40° NW.; width 12 in. Ore shipped to Burton Bros., Inc., amounted to $2000. Three men are employed.

Bibl.: State Mineralogist's Report XV, pp. 804-807.

Morning Star. The property comprises 18 claims located on the east slope of the Providence Mountains, in the Mescal Mining District, in Sec. 27, 28, 33 and 34, T. 15 N., R. 14 E., S. B. M., 8 miles north of Cima; elevation 4400 ft.; owners, J. B. Mighton, Cima, Calif., and H. T. Brown, Los Angeles; under option to Erle P. Halliburton, Inc., 907 National City Bank Bldg., Los Angeles; E. P. Halliburton, president and manager; H. V. Hughes, superintendent. During 1937 and 1938, the property was under option to Richard W. Malik, Los Angeles, during which period a number of crosscuts and winzes were made on tunnel level. In April, 1939, Mr. E. P. Halliburton started operations on the property.

The vein occurs as a rhyolite-porphyry intrusive in quartz-diorite which strikes N.-S. and dips 34° W. The width of this porphyry dike is about 350 ft. The vein material is highly silicified and the mineralization occurs along a series of more or less parallel east and west fractures in the dike itself. The ore is quartz, heavily mineralized with pyrite. The values vary from $2 to $15 per ton in gold, with averages said to be $4 to $6 per ton, 25% is in fine gold, the remaining values being in the pyrite.

Development consists of a tunnel driven 600 ft. north along the footwall of the dike which is 350 ft. vertically below outcrop. Crosscuts have been driven at intervals to determine width of ore body. These crosscuts indicate an average width of 300 ft. Present development work is confined to shaft sunk on the footwall to a depth of 250 ft.

Equipment consists of gas-driven hoist and Gardner-Denver compressor. Ten men are employed.

Bibl.: State Mineralogist's Report XXVII, pp. 304-305.

New Discovery Mine (tungsten). It comprises 6 claims situated in the Mirage Lake District, in Sec. 6, T. 6 N., R. 6 W., S. B. M., 14 miles west of Adelanto and 23 miles northwest of Victorville; elevation 3000 ft.; owners, Nicholas Baxter, San Bernardino, and Oliver Adams, Los Angeles.

The general strike of the lime-silicate rocks carrying values in scheelite is N.-S., dip 60° W. Width of mineralized zone is 25 ft. to 90 ft. Developments consist of shallow shafts and opencuts 10 ft.

to 15 ft. in depth. General average value of ore extracted is said to be 0.3% to 0.5% WO_3; sorted ore 1% to 1.5% WO_3. Three men are employed on development.

Prosperity Group of Mines (Golden Star). It comprises 10 claims situated on the northeast slope of the Turtle Mountains, 26 miles southwest of Needles; elevation 2000 ft.; owner, Charles H. Brown, Needles, Calif.; under option to the *Golden Star Mining Co.*, A. S. Highstone, president and manager.

Three parallel veins occur in granite, strike E.-W., dip 30° S.; width 18 in. to 2 ft. The veins are about 30 ft. apart. Vein quartz shows free gold associated with pyrite and chalcopyrite. Development consists of incline shaft sunk on the vein to a depth of 100 ft., with 100 ft. of drifting on the 50-ft. level. About 3000 ft. west of this shaft, a shaft has been sunk on the vein to a depth of 150 ft. All present work is confined to East shaft.

Mine equipment consists of 50-h.p., 2-cylinder Fairbanks-Morse diesel engine, direct-connected with Westinghouse generator; portable compressor. Mill has a capacity of 25 tons; 8-in. by 15-in. Wheeling crusher to fine-ore bin, capacity 50 tons; then by belt feeder to 3-ft. by 4-ft. Gibson rod mill, equipped with eliptic roll. Ore is ground to minus 80-mesh. Pulp from mill goes to Gibson amalgamator from which it flows to Gibson concentrator. Fifteen men are employed.

Ramsey Mine (Wheeler). The property comprises 12 claims situated on the ridge south of Grapevine Canyon, in Sec. 2 and 3, T 3 N., R. 2 W., S. B. M., on the east slope of the San Bernardino Mountains, 15 miles southeast of Victorville and 5 miles south of Fifteenmile Point; elevation 4500 ft. to 6000 ft.; owner, Ramsey Mining Co., Milton G. Ramsey, president and manager. This company acquired the property the latter part of 1936 and the property has been under operation to date.

Two parallel veins about 500 ft. apart, occur in gneissoid granite. These veins occur along diorite dikes, the diorite being on the footwall of the quartz veins in granite. The West vein strikes N. 20° W. and dips 25° W. The East vein strikes N.-S. and dips 50° to 70° W. Widths vary from 6 in. to 4 ft. As a rule when the veins pinch to a width of 6 in. to 12 in., the values increase. The vein quartz is mineralized with free gold, associated with pyrite and chalcopyrite. The veins can be traced along the surface outcrops for a distance of 6000 ft.

Development: The principal development at present is confined to the West vein. About three-quarters of a mile south of the mill at an elevation of 6000 ft., a shaft has been sunk on an inclination of 80°, intersecting the vein at a depth of 40 ft. Then the remaining distance of 60 ft. is on the vein which has a dip of 25°. Drifts have been driven north and south on the 40-ft. level and also on the 65-ft. level. North of the shaft, a tunnel has been driven south on vein a distance of 40 ft. This tunnel will intersect shaft on 40-foot level. The vein has been underhanded stoped for a distance of 20 ft. to a depth of 10 ft. The vein has an average width of 3 ft. and is reported to carry values from $20 to $50 per ton in gold. About 500 ft. north of the shaft, a tunnel has been driven north 150 ft., with 50 ft. of

backs. Ore is stoped to surface for a length of 50 ft. About 500 ft. north of these workings, a tunnel has been driven south on the vein a distance of 200 ft. Ore shoot 100 ft. in length, 2 ft. wide, is stoped to surface for a distance of 60 ft. Two winzes are being sunk from tunnel level. One is 100 ft. in depth, the other 150 ft. deep. About 200 ft. north of No. 1 shaft, a crosscut tunnel has been driven west 200 ft. to the vein, with drift south on the vein 150 ft.

Ore mined from the above-mentioned workings is hauled by tractor in trailer having a capacity of 2 tons to the mill. In canyon about one-half mile northeast of the mill, a tunnel has been driven south 600 ft. on East vein, about 200 ft. below the outcrop. Average width of vein is 2 ft. There is also a series of east-west veins but only developed so far by shallow opencuts.

Mine equipment consists of 2 Ingersoll-Rand compressors, one with a capacity of 100 cu. ft., the other with a capacity of 70 cu. ft.; one Ingersoll-Rand tugger hoist and 15-h.p. single drum Novo gas engine hoist.

Mill: 25-ton counter-current cyanide plant. Mine run of ore to 8-in. by 9-in. Blake-type of crusher to 25-ton ore bin. From bin ore is fed by belt type of feeder to 4-ft. by 4-ft. Cotrell ball mill, in closed circuit, with Aiken classifier. Ore is ground to minus 80 mesh. Between classifier and ball mill discharge, is a Denver jig to remove coarse gold. Overflow from classifier to Plato concentrator, from which high-grade concentrate cut, is said to have a value of $200 per ton in gold. Tails from table to 8-ft. by 20-ft. Dorr thickener, then thickened pulp is pumped by Dorco pump to three 14-ft. by 14-ft. agitators. The solution from agitators is pumped by Dorco pump to 8 ft. by 16-ft. Dorr thickener. Merrill-Crowe Precipitation Process: The gold solution from Dorr thickener is pumped to 8-ft. by 16-ft. gold solution tank. The gold solution from gold tank is gradually pumped into an 8-ft. by 10-ft. clarifier tank where the waste material is filtered from the gold and water-cyanide solution. The gold-cyanide solution is fed into top of the deaerator tank. The vacuum pump creates a vacuum at the top of the deaerator tank and the gold solution flows from bags into the top of the deaerator tank and settles to the bottom of tank. The precipitate pump located beneath the zinc feeder machine pumps the solution from bottom of deaerator tank past check valve where zinc is added and on to precipitation tank equipped with cloth bags. The gold and zinc remain within the bags, while water-cyanide solution flows on out to be pumped back into barren solution tank for use in system again.

Power plant consists of 90-h.p., 3-cylinder Fairbanks-Morse diesel engine, direct connected, with 45 K. V. A. generator. Mill equipment is driven by individual motors. Water for mill is secured from springs and mine through 2-in. pipeline, one-half mile in length. Grade of ore treated is reported to be from $20 to $50 per ton in gold, recovery being from 90% to 95%. Consumption of cyanide is ½ lb. of sodium cyanide per ton. Production is $4000 per month. Ten men are employed.

Reward Mine. It comprises 4 patented claims situated in the Goldstone Mining District, in Sec. 2, 3, 10 and 11, T. 13 N., R. 1 E., S. B. M., on the north slope of the Paradise Mountains, 26 miles north

of Barstow and 12 miles north of Paradise Springs; elevation 4600 ft.; owner, Reward Mining Co., Julian Itter, president and manager, Beverly Hills, Calif; J. N. Thiele, secretary, Santa Paula, Calif.

The Reward vein occurs in schist, strike N. 30° W., dip 75° W. Width varies from 2 ft. to 6 ft. A lime-silicate dike forms the footwall of the vein, with schist hanging wall. A tunnel has been driven N. 30° W. 600 ft. At 50 ft. north of portal of the tunnel developed an ore shoot 150 ft. in length, with an average width of 4 ft. Two raises have been put up to the surface, a distance of 60 ft. Ore is stoped out. These raises are 125 ft. apart. At 350 ft. from portal of tunnel cut lime-silicate dike. The vein quartz shows free gold associated with pyrite, chalcopyrite and marcasite. Ore milled is stated to have an average value of $30 per ton in gold. At 570 ft. from the portal of tunnel on contact of lime-silicate dike, developed some small lenses of copper ore. The mineral was chalcopyrite associated with pyrite. Samples taken stated to carry from 4 per cent to 15 per cent copper, with $1.40 per ton in gold. At this point, a winze was sunk on an inclination of 20° to a depth of 112 ft.

About 7 miles west of the mine, the company drilled a well 375 ft. deep, developing water and installed a 20-ton amalgamation mill. After short operation, the mill was sold to L. V. Storrs, of Hollywood, Calif. Idle.

Bibl.: State Mineralogist's Report XXXIV, p. 15.

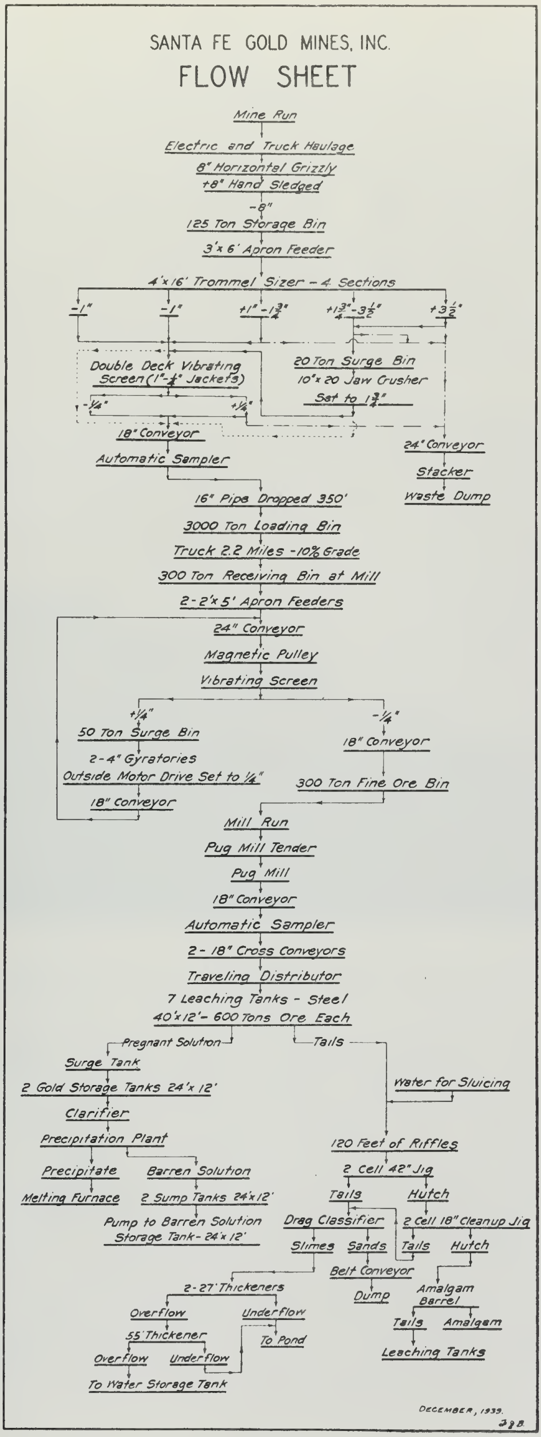
Rio Hondo Mine. It comprises 6 claims situated in the Goldstone District, 2 miles northeast of Reward Mine and 28 miles north of Barstow; elevation 4350 ft.; owner, Vernon Jay, Barstow, Calif.

The formation is schist, limestone and granite. A quartz vein occurs in limestone, strike N. 50° W., dip 80° N.; width 3 ft. to 6 ft. Ore developed is reported to carry from $7 to $15 per ton in gold. The quartz carries free gold associated with pyrite. Development consists of opencut 100 ft. in length, and 4 ft to 6 ft. in depth; shaft 72 ft. deep and about 50 ft. southeast, a shaft 90 ft. deep; tunnel 20 ft. long.

Mine equipment consists of a Chicago Pneumatic Hot Head compressor. Mill: 10-in. by 12-in. Universal crusher; 4-ft. by 4-ft. ball mill; Dorr classifier and amalgamation plates. Idle.

Santa Fe Mines (Arlington & Black Hawk Mines). The property comprises a group of 175 claims known as the Black Hawk Group of Mines, situated in Sec. 5, 8, 9, 16 and 17, T. 3 N., R. 2 E., S. B. M., on the east slope of the San Bernardino Mountains, 35 miles southeast of Victorville; elevation 4200 ft. to 6700 ft.; original owner, *Arlington Mining Corp.*, Algernon Del Mar, President; R. K. Voorhies, secretary. The property was recently acquired by the Santa Fe Gold Mines, Inc., Hewitt S. West, president; W. Lunsford Long, chairman of the board; Harlan H. Bradt, Managing engineer; J. E. Moore, Jr., general superintendent; Algernon Del Mar, consulting metallurgist; offices, 55 Liberty St., New York, N. Y. Local offices are in Pacific Southwest Bldg., Pasadena, Calif.

The formations that occur in the vicinity of Black Hawk Canyon are gneissoid granite, overlain by white, gray or reddish metamorphic limestone and a series of interbedded sandstone. Along Black Hawk


SANTA FE GOLD MINES, INC.
FLOW SHEET
Mine Run
Electric and Truck Haulage
8" Horizontal Grizzly
+8" Hand Sledged
-8"
125 Ton Storage Bin
3'x 6' Apron Feeder
4'x 16' Trommel Sizer - 4 Sections
-1"
-1"
+1" -1¾"
+1¾" -3½"
+3½"
Double Deck Vibrating Screen (1"-¼" Jackets)
-¼"
+¼"
20 Ton Surge Bin
10"x 20 Jaw Crusher
Set to 1¾"
18" Conveyor
Automatic Sampler
24" Conveyor
Stacker
Waste Dump
16" Pipe Dropped 350'
3000 Ton Loading Bin
Truck 2.2 Miles -10% Grade
300 Ton Receiving Bin at Mill
2-2'x 5' Apron Feeders
24" Conveyor
Magnetic Pulley
Vibrating Screen
+¼"
50 Ton Surge Bin
2-4" Gyratories
Outside Motor Drive Set to ¼"
18" Conveyor
-¼"
18" Conveyor
300 Ton Fine Ore Bin
Mill Run
Pug Mill Tender
Pug Mill
18" Conveyor
Automatic Sampler
2-18" Cross Conveyors
Traveling Distributor
7 Leaching Tanks - Steel
40'x 12' - 600 Tons Ore Each
Pregnant Solution
Tails
Surge Tank
2 Gold Storage Tanks 24'x 12'
Clarifier
Precipitation Plant
Precipitate
Barren Solution
Melting Furnace
2 Sump Tanks 24'x 12'
Pump to Barren Solution
Storage Tank - 24'x 12'
Water for Sluicing
120 Feet of Riffles
2 Cell 42" Jig
Tails
Hutch
Drag Classifier
2 Cell 18" Cleanup Jig
Slimes
Sands
Tails
Hutch
Belt Conveyor
Dump
Amalgam Barrel
Tails
Amalgam
Leaching Tanks
2-27' Thickeners
Overflow
Underflow
55' Thickener
To Pond
Overflow
Underflow
To Water Storage Tank
DECEMBER, 1939.

Canyon, the limestone is in the form of a breccia slightly silicified, with red iron (hematite) streaks running through the brecciated mass that gives it a pinkish or reddish color. The fragments are slightly cemented together, stained red, being principally calcite, with some dolomite and fine, irregular grains of quartz. The footwall of the ore zone is granite, with a hanging wall of massive limestone. The Black Hawk lode which follows along Black Hawk Canyon strikes N. 20° E. and dips 5° to 20° SW. The Arlington-Santa Fe lode strikes N. 80° E. and dips 5° to 20° S. The crushed zone is at least 100 ft. thick, with a gneissoid granite footwall and limestone hanging wall. The gold occurs in the soft material that forms the filling between the crushed fragments and not in the pieces of hard rock. The richest ore is found in hematite streaks that occur at intervals throughout the crushed zone, and the whole is free-milling. At present ore is being

Photo by R. K. Voorhies

600-ton Sand Leaching Plant, Santa Fe Mines, San Bernardino Co.

mined from the Arlington-Santa Fe lode at an elevation of 6200 feet along the lode. A workings: Consist of an opencut 200 ft. in length along the strike of the lode, with a height of 50 ft. above the floor of the cut. A ½-yd. P & H shovel loads ore into trucks for delivery to screening plant. B workings: Consist of crosscut tunnel driven south 400 ft.; connects with glory hole. Ore is hauled by train of 10 cars, with a capacity of 2 tons each, by storage-battery locomotive to receiving bins at screening plant. Farther west is crosscut tunnel No. 2 driven south 400 ft. connecting with a glory hole. C workings: Ore from this crosscut tunnel is delivered on train to receiving bin. About 500 feet east of Calle de Oro Mine workings, is an opencut about 100 ft. in length and 50 ft. in height. Ore from these workings is delivered by caterpillar tractor to ore bin from which it goes through 16-in. pipeline to main receiving bin.

Upper screening and crushing plant: (See flow sheet) Ore from different mine workings is dumped onto railroad-iron grizzly, spaced 8 in. apart to ore bin having a capacity of 125 tons. Ore from bin is fed by 3-ft. by 6-ft. apron feeder to 4 ft. in diameter by 16 ft. in length trommel made in sections as follows: One section of $3\frac{1}{4}$-in. size, one section of $1\frac{3}{4}$-in. size, 2 sections of 1-in. size openings. The plus $3\frac{1}{4}$-in. material goes from trommel to waste bin, then to 24-in. belt conveyor to waste dump. Minus $3\frac{1}{4}$-in. and plus $1\frac{3}{4}$-in. to 20-ton surge bin to a 10-in. by 20-in. Blake type of crusher, set to $1\frac{3}{4}$-in.; driven by 50-h.p. motor (not operating). The $1\frac{3}{4}$-in. to minus $1\frac{3}{4}$-in. to minus 1-in. size material from trommel goes to double-deck Kennedy-Van Sant vibrating screen. It is screened to minus $\frac{1}{4}$-in.; oversize from screens to bin, then to 24-in. belt conveyor to waste dump. Oversize waste material is reported to carry 7 cents per ton in gold. The $\frac{1}{4}$-in. size material goes to bin with a capacity of 100 tons. From bin it goes to 18-in. belt conveyor equipped with magnetic pulley; then to 100-ton fine-ore bin from which it flows by gravity through 10-in. pipe 350 ft. in length to storage bin with a capacity of 3000 tons. From storage bins, it is hauled by trucks with a capacity of 11 tons each, a distance of 2.2 miles to lower receiving plant. Cost of hauling under contract is 18 cents per ton. Trucks dump $\frac{1}{4}$-in. ore into bin having a capacity of 300 tons. Ore from 300-ton bin fed by two 2-ft. by 4-ft. apron feeders to 24-in. belt conveyor, equipped with magnetic pulley to Kennedy-Van Sant vibrating screen which screens the ore to plus $\frac{1}{4}$-in. and minus $\frac{1}{4}$-in.; oversize to 50-ton surge bin, from which it is fed by gate feeders to 2 Kennedy-Van Sant gyratory crushers (each driven by 30-h.p. motors); crushed to minus $\frac{1}{4}$-in.; then to 18-in. belt conveyor, to 24-in. belt conveyor that carries the minus $\frac{1}{4}$-in. product to tower sampler; from tower sampler to bin with a capacity of 300 tons. From bin, ore is fed by Pug-mill tender feeder to Pug mill. A small amount of water is added to Pug-mill tender. From Pug mill the ore goes to 18-in. belt conveyor, to two 18-in. cross belt conveyors over seven 12-ft. by 40-ft. steel and sand-leaching tanks. From the cross belt conveyors, over the tank to be loaded to Kennedy-Van Sant Distributor which loads tanks uniformly. Each tank has a capacity of 600 tons of ore. Cyanide solution is fed through bottom of tanks. Time of contact is 120 hours. One tank is emptied every 7 days. Gold solution goes from leaching tanks to two 12-ft. by 24-ft. gold solution tanks, then to 8-ft. by 10-ft. clarifier tank with filter leaves, then to Merrill-Crowe precipitation process. Barren solution is pumped to two 12-ft. by 24-ft. barren solution tanks; pumped to 12-ft. by 24-ft. storage tank; sands from leaching tanks to 120-ft. sluice box equipped with riffles to 2-cell 42-in. Pan American jig; hutch product from jig to 2-cell 18-in. cleanup jig; hutch product from cleanup jig to amalgamation barrel and tails from amalgamation barrel returned to leaching tank; tails from 2-cell 42-in. jig and tails from 2-cell 18-in. cleanup jig to Dorr drag classifier; sands from classifier to 18-in. belt conveyor to waste dump; slimes from classifier to two 27-ft. Dorr thickeners; overflow from thickeners to 55-ft. Dorr thickener and overflow from thickener pumped to water storage tank and underflow from thickeners to tailings pond.

Water for camp and milling operations is secured from Arrastra Creek through 5-in. pipeline, 4½ miles in length; flows by gravity to 11-ft. by 34-ft. storage tank, with a capacity of 35,000 gal. Electric power is secured from the Southern Sierras Power Co., over a power line 6 miles long from sub-station in Arctic Canyon. Fifteen men are employed in mill, 35 men at mine, camp 10 men, total employed being 60 men.

Bibl.: State Mineralogist's Reports IX, p. 226; X, p. 524; XI, p. 364; XII, p. 230; XIII, p. 330; XV, pp. 797-798; XXVII, pp. 282-286.

Shadow Mountain Mines (tungsten). The property comprises 30 claims situated on the north slope of Shadow Mountain, in Sec. 30 and 31, T. 8 N., R. 6 W., S. B. M., 15 miles north of Adelanto and 21 miles northwest of Victorville; elevation 3500 ft.; owner, *Just Associates, Inc.*, E. Richard Just, president; Oliver Adams, secretary; offices, 117 W. 9th St., Los Angeles.

During the latter part of 1937, Nicholas Baxter discovered scheelite in crystalline limestone in this area and located a large number of claims. In January, 1938, these claims were acquired by the Just Associates, Inc., and prospecting and development work started on the property. The Shadow Mountain Tungsten Mines, Inc., Fay Wright, president, 811 W. 7th St., Los Angeles, secured an option on the property in May, 1938, and interested Rasmussen and Trout of the Macco Construction Co. in the deposit. This company dug 1800 ft. of trenches to a depth of 6 ft. to 10 ft. with power shovel. The work consisted of a series of zigzag trenches starting at the foot of the mountain and extending up the hill a distance of 1800 ft. to an elevation of 200 ft. During the latter part of 1938, a 60-ton portable concentration plant was installed on the property and treated about 300 tons of ore but the results were not satisfactory and operations were suspended.

The scheelite occurs in the limestone along the bedding planes and in a garnetiferous rock near contact of limestone and schist. The mineralized zone is 1100 ft. in length by 130 ft. in width, strikes N.-S. and dips 35° E. Along the contact of schist is a large sill of quartz-feldspar aplite which shatters the formation, extending into the crystalline limestone for a short distance. The solutions that emanated from the intrusive magma have sealed the fractures and penetrated by replacement the crystalline limestone, depositing scheelite and silica and developed garnet and epidote as gangue minerals along the old structure of the limestone. The limestone belt is approximately 450 ft. thick. The ore exposed in the trenches and a shaft 60 ft. deep, is reported to carry from 0.25% to 1.5% WO_3. High grade, selected samples carry as high as 15% WO_3. Six men are employed.

Sulphide Queen Mine. The property comprises 7 claims situated in the Clark Mountain Mining District, 2½ miles north of Mountain Pass and 19 miles southwest of Roach, a station on the Union Pacific Railroad; elevation 5100 ft.; owner, Fred B. Piehl, Nipton, Calif.

The formation is gneissoid granite, with intrusions of aplite dikes that strike N. 30° W. The principal development is on a vein which occurs on contact of an aplite dike and granite. The aplite dike forms

the hanging wall of the quartz vein, with gneissoid granite footwall. The vein has a width of 12 ft. to 15 ft., strikes N. 32° W. and dips 70 to 80° W. Development consists of a shaft sunk on an inclination of 60° to 114-ft. level, then on 55° to 237-ft. level, with levels at 114 ft. and 213 ft. On the 114-ft. level, drift northwest 180 ft. and southeast 90 ft.; on 213-ft. level, drift 150 ft. northwest and 60 ft. southeast. Ore shoot developed on 213-ft. level, is 100 ft. in length. The average width is 12 ft. Total amount of ore developed is estimated to be 15,000 tons, with an average value of $9 gold per ton. On the 213-ft. level, about 100 ft. northwest of shaft, is a crosscut driven northeast 47 ft.; cut vein in face of crosscut. There is an adit tunnel driven northeast 135 ft. connecting with shaft on 65-ft level. Vein quartz, mineralized with hematite and pyrite, shows free gold; sinking shaft to 300-ft. level.

Mine equipment consists of 20-h.p. Fairbanks-Morse hoist; Chicago pneumatic compressor with a capacity of 300 cu. ft.; blacksmith shop and truck. Six men are employed on development.

Top Nest Mine. It comprises 6 claims situated in Dale Mining District, on the east slope of the Dale Mountains, in Sec. 7, T. 1 S., R. 13 E., S. B. M., 3 miles northeast of New Dale and 22 miles east of Twenty-nine Palms; elevation 3000 ft.; owner, *Hayward Lumber Co.*, Palm Springs, Calif.; under lease to E. G. Johnson, Palm Springs, Calif. The property adjoins the Ivanhoe group of claims on the northwest.

The Top Nest vein occurs in andesitic porphyry; strike N. 20° W., dip 80° E. Width varies from 2 ft. to 6 ft. The vein quartz is stained with copper oxides and shows considerable hematite and some free gold associated with chalcopyrite and bornite. Development consists of 4 tunnels at different elevations driven on the vein. These tunnels vary in length from 200 to 600 ft. From lower tunnel, there is a jig-back aerial tram to bin with a capacity of 25 tons. Ore is loaded into trucks and hauled to Sunrise mill in Pinto Basin for treatment. Six men are employed.

Telegraph Mines. The property comprises 5 claims situated in Sec. 16 and 17, T. 15 N., R. 11 E., S. B. M., in the Solo Mining District, 17 miles east of Baker, a station on the Tonopah & Tidewater Railroad; elevation 3500 to 4000 ft.; owner, Telegraph Mines, Inc., J. T. Hutton, president; Andrew Bauer, secretary, Long Beach, Calif.; under lease to Solo Engineering Co., C. F. Robbins, president and manager, Long Beach, Calif.

The property was located on November 19, 1930, by Ralph and A. A. Brown of Salida, Utah. Discovery of a high-grade streak of ore was made on Telegraph Extension Claim which caused a revival of mining activity in this old district. O. Perry Riker of Long Beach operated the property under lease from December, 1932, to January, 1935. During this period he shipped 220 tons of ore to the mill at Yucca Grove, operated by the Consolidated Metal Mines, Ltd., of Salt Lake City, Utah. The ore treated was reported to have an average value of $16 per ton in gold; also shipped to smelter 909 tons; value $18,963. Solo Engineering Co. has a lease and option on the property

from September, 1935, to date. Total production of the property to date has been $35,200.

Calcite-quartz vein occurs in granite, with a strike of N. 30° E., and dip of 30° to 50° NW. Width of vein varies from 4 ft. to 8 ft. The vein occurs along aplite dike that has the same general strike and dip. This dike forms the footwall of the vein with a granite hanging wall. Since the Twenty-seventh Report of the State Mineralogist, pp. 332, the following amount of development has been done on the property: On South Telegraph Claim, at an elevation of 3750 ft., a shaft has been sunk on an inclination of 52° to a depth of 125 ft.; on the 75-ft. level, drift north 250 ft. on vein, with drift south 115 ft. Ore shoot developed on this level is 250 ft. in length; average width 6 ft. It is reported to have an average value of $9 per ton in gold. On Telegraph Extension Claim, a shaft has been sunk on the vein to a depth of 100 ft. The dip of the vein is 35° W.; width 6 ft. to 8 ft. Two hundred tons of ore mined and milled from Telegraph Extension

No. 1 Shaft, Telegraph Mines, Solo Mining Dist., Yucca Grove, San Bernardino Co.

shaft is reported to have had an average value of $16 per ton in gold. Present work is confined to shaft on South Telegraph Claim.

Mine equipment consists of C. P. compressor, capacity 110 cu. ft.; also Garden-Denver compressor, with a capacity of 118 cu. ft.; 12-h.p. Western gas engine hoist.

Mill equipment consists of 25-ton ore bin; 8-in. by 10-in. Blake crusher; 3-ft. by 6-ft. Hartman ball mill in closed circuit, with Simplex Dorr classifier, ground to minus 60-mesh, then to 8-ft. K & K flotation machine; tails to waste. Concentrates produced are reported to carry $300 to $400 per ton in gold. Six men are employed.

Bibl.: State Mineralogist's Report XXVII, p. 332.

Uncle Sam Mine. It comprises 5 claims situated in the Goldstone Mining District, 2 miles southeast of Goldstone and 33 miles north of Barstow; elevation 3500 ft.; owner, L. W. Storrs, Los Angeles.

The vein occurs in schist and clay shales; strike NW.-SE., dip 60° NE.; width 2 ft. Development consists of shaft sunk on the vein to a

depth of 110 ft., with levels at 50 ft. and 100 ft., with about 500 ft. of drifts.

Mine equipment consists of hoist and compressor. Ore is hauled by truck a distance of 5 miles to the Reward mill which has a capacity of 20 tons per 24 hr. The mill was purchased from the Reward Mining Co.

Mill equipment consists of 25-ton ore bin; 6-in. by 8-in. Blake type crusher; 3-ft. by 4-ft. ball mill, amalgamation plates and 2 K & K flotation machines. Ten men are employed.

BENTONITE

California Talc Company's Bentonite Deposit. The property comprises fourteen 160-acre placer claims, approximately 2220 acres, situated in Sec. 31, T. 9 N., R. 5 E., and in Sec. 22, 23, 24, 26 and 27, T. 8 N., R. 5 E., S. B. M., the Lemon or south deposits being located 3 miles south of Hector and the north deposits are located $3\frac{1}{2}$ miles west of Hector, a station on the Santa Fe Railroad; elevation 2000 ft.; owners, *National Pigments & Chemical Division* of the *National Lead Co.;* offices, 837 Jackson St., Los Angeles, Geo. L. Radcliffe, president; R. E. Scott, secretary and manager; Percy Stamdinger, superintendent.

The deposit is the largest and purest deposit of bentonite in California and has been a steady producer since 1931. Bedded deposit of bentonite that is covered by flow of basalt and rhyolite. The beds strike northwest and southeast; dips vary from 12° to 20° to SW. The thickness of the bentonite beds vary from 6 ft. to 40 ft. The basalt overlying the bentonite beds is from 12 ft. to 15 ft. thick. The bentonite mined is white to gray in color. It is reported to be equal in quality to Wyoming bentonite. The material is manufactured and sold under the trade name of ''Aquagel,'' a conditioning compound for oil-well rotary mud; also as an admixture for concrete.

The present development is confined to the Lemon Group south of Hector. Development: The company drilled 11 core-drill holes in this area exposing extensive beds of bentonite. In Sec. 26 and 27, T. 8 N., R. 5 E., they stripped off the basalt to a depth of 20 ft., an area 400 ft. in length by 400 ft. in width. From the floor of this opencut a series of incline shafts have been sunk on inclination of 15° to depths of 200 ft., with drifts connecting the shafts. The bentonite mined is hoisted by two 15-h.p. gas engine hoists to bunkers. From bunkers, it is loaded in trucks and hauled to drying platform at Hector Siding. The material is sun dried, then loaded into railroad cars for shipment to the company's grinding plant in Los Angeles. Grinding plant is located on the Santa Fe Railroad tracks at 837 Richmond St. Bentonite from railroad cars goes to Acme jaw crusher, then elevated by bucket elevator to 5-ft. by 16-ft. trommel, oversize to Symons disc crusher, then product from crusher elevated to ore bin. From bin, the material is delivered by reciprocating feeder to 2 Bethlehem pulverizers; then by air separator to cyclone dust-collector, to bag house and finished-product bins; from finished-product bins to Howe packer machines. The grinding plant has a capacity of 75 tons per day. The product produced is 75 per cent through 200-mesh screen.

Analysis of bentonite by Smith-Emery Co.

Silica (SiO_2)	52.32%
Aluminum oxide (Al_2O_3)	18.74%
Titanium oxide (TiO_2)	0.10%
Iron oxide (Fe_2O_3)	1.20%
Calcium oxide (CaO)	0.96%
Magnesium oxide (MgO)	4.35%
Potassium oxide (K_2O)	0.41%
Sodium oxide (Na_2O)	4.98%
Sulphuric anhydride (SO_3)	0.33%
Chlorine (Cl)	1.03%
Phosphoric anhydride (P_2O_5)	0.04%
Moisture combined (H_2O)	15.54%
	100.00%

Thirty men are employed.

GRANITE

Texas Quarries Granite Deposit. The property comprises 160 acres situated in Sec. 29, T. 5 N., R. 2 E., S. B. M., 35 miles east of Victorville and 8 miles east of Lucerne; elevation 3700 ft.; owner, Texas Quarries, Inc., Austin, Texas; W. H. Johnson, president; C. H. Owens, vice president and manager; J. J. Kell, superintendent.

A massive outcrop of granodiorite occurs in a series of granite hills that strike north and south. The color of the granite quarried is pearl white to oxford gray, of very fine texture and hardness.

The quarry is 200 ft. in length by 100 ft. in width. Equipped with 30-ton Insley steel derrick, with 100-ft. boom. A 125-h.p. caterpillar diesel engine drives winch; also 300-cu. ft. Ingersoll-Rand compressor. Sizes of granite blocks quarried are as follows: 11 ft. 4 in. by 3 ft. 10 in. by 2 ft. 10 in.; 8 ft. by 3 ft. 6 in. by 2 ft. 6 in.; 9 ft. 4 in. by 7 ft. 5 in. by 10 in.

The granite is hauled by trucks to finishing plant at Victorville. Equipment consists of 30-ton steel derrick, with 80-ft. boom; polishing machines; 2 wire-cutting machines; 3 finishing machines and 150-cu. ft. compressor.

The finished product shipped is known as Lucerne Golden Vein Granite, Lucerne Oxford Granite, Lucerne Pearl White Granite. Twenty-five men are employed.

GEOLOGIC BRANCH

CURRENT NOTES

By Olaf P. Jenkins, Chief Geologist

In the Next Issue

Since Mono County will be the principal feature of the next or April issue of the California Journal of Mines and Geology, the Geologic Branch is publishing a paper prepared by Alfred L. Ransome (now a member of the staff), "General Geology and Ores of the Blind Spring Hill Mining District." This district is located between Benton Range and the White Mountains, north of Bishop, in Mono County. Mr. Ransome's paper was originally prepared as a thesis for an M.A. degree in geology at Stanford University in 1938.

In Preparation

Part One of the new Bulletin 118, "Geologic Formations and Economic Development of the Oil and Gas Fields of California," is now in press. This book will be a comprehensive treatise on the geology of California, especially as it is related to the oil and gas industry of the State. The following is the table of contents for Part One:

Chapter I—Development and Production

Economics of the Oil and Gas Industry of California,
by J. R. Pemberton.
Taxation and Its Relation to Development and Production,
by Granville S. Borden.
Historical Production, Stocks and Shipments Charts,
by H. L. Scarborough.

Significant Statistics, by Wm. R. Wardner, Jr.
Table I—Los Angeles Basin.
Table II—San Joaquin Valley.
Table III—Coast and Transverse Ranges.

Analysis of California Petroleum Reserves and Their Relation to Demand and Curtailment, by Wm. R. Wardner, Jr.
Natural Gas Fields of California, by Roy M. Bauer and John F. Dodge.

Chapter II—Exploration

Development of Engineering Technique and Its Effect Upon Exploration for Oil and Gas in California,
by Lester C. Uren.

Mechanics of California Reservoirs, by Stanley C. Herold.
Geophysical Studies in California, by F. E. Vaughan.
Geochemical Prospecting for Petroleum, by E. E. Rosaire.

Chapter III—Early History

Aboriginal Use of Bitumen by the California Indians, by Robert F. Heizer.

History of Exploration and Development of Gas and Oil in Northern California, by Walter Stalder.

The headings of the four parts which will comprise the whole book are as follows:

Part One—Development of the Industry.

Part Two—Geology of California and the Occurrence of Oil and Gas.

Part Three—Descriptions of Individual Oil and Gas Fields of California.

Part Four—Glossary, Bibliography and Index, and Outline Geologic Map of California Showing Oil and Gas Resources.

The plan is to take subscriptions for the four parts of this bulletin, a limited supply of each part of which is to be bound in paper and distributed as "pre-prints." When the last part is printed the main supply of all four parts will be bound in cloth and issued as one large volume. The full size of the page is $8\frac{1}{2}'' \times 11''$, which is nearly twice the size of the CALIFORNIA JOURNAL OF MINES AND GEOLOGY, and will thus accommodate on the single pages, maps, charts, and tables with which the bulletin is to be profusely illustrated.

SPECIAL ARTICLES

Detailed technical reports on special subjects, the result of research work or extended field investigations, will continue to be issued as separate bulletins by the Bureau, as has been the custom in the past.

Shorter and less elaborate technical papers and articles by members of the staff and others are published in each number of CALIFORNIA JOURNAL OF MINES AND GEOLOGY.

These special articles cover a wide range of subjects both of historical and current interest; descriptions of new processes, or metallurgical and industrial plants, new mineral occurrences, and interesting geological formations, as well as articles intended to supply practical and timely information on the problems of the prospector and miner, such as the text of new laws and official regulations and notices affecting the mineral industry.

"THE PUBLIC'S INTEREST IN MINE TAXATION." The special article under this title by A. G. Mackenzie in our April quarterly was printed without the credit line which should have read: Reprinted by permission of the American Mining Congress, Washington, D. C."

NOTES ON BERYL WITH A QUALITATIVE ANALYSIS FOR BERYLLIUM

By George L. Gary, Mineral Technologist

Beryllium is one of the metals which has had an unusual amount of public interest recently as evidenced by the inquiries and samples that have been sent to the laboratory of the State Division of Mines in the past year.

In accordance with our usual policy of keeping the mining interests of the State informed of minerals for which there is a market we are submitting herewith a paper on the physical and chemical properties of the mineral beryl, the principal source of beryllium; a test for beryllium; the occurrence of beryl in California and general information of timely value. It is compiled from a number of sources and a bibliography will be found at the end of the paper.

BERYL

Physical Properties. Beryl occurs in hexagonal crystals usually long prismatic, often striated vertically, rarely transversely; distinct terminations exceptional. Occasionally in large masses, coarse granular or granular to compact. Cleavage; imperfect and indistinct. Fracture conchoidal to uneven. Brittle. Hardness. 7.5-8.0. Gravity. 2.63-2.80; usually 2.69-2.70. Luster vitreous, sometimes resinous. Colors emerald-green, pale green, passing to light blue, yellow and white; also pale rose red. Streak white. Transparent to subtranslucent. Variety 1. Emerald. Color bright emerald-green, due to the presence of a little chromium. 2. Ordinary; Beryl. Generally in hexagonal prisms, often coarse and large; green the common color. The principal kinds are: (a) colorless; (b) bluish-green, called *aquamarine;* (c) apple-green; (d) greenish-yellow to iron-yellow and honey-yellow; sometimes a clear bright yellow as in the *golden beryl* (a yellow gem variety from South West Africa has been called *heliodor,* containing a small amount of ferric oxide); (e) pale yellowish-green; (f) clear sapphire blue; (g) pale sky-blue; (h) pale violet or reddish; (i) rose colored called *morganite or vorobyevite*; (j) opaque brownish-yellow, of waxy or greasy luster. The *oriental emerald* of jewelry is emerald-colored sapphire.

Composition. Until recently regarded as a rare element, beryllium, sometimes called glucinum, Gl, is found in the common mineral beryl which corresponds to the formula $3BeO.Al_2O_3.6SiO_2$. This composition is theoretically a content of 13.9% BeO, 19% Al_2O_3 and 67% SiO_2. Usually, the beryllium content of beryl is even less. Nature does not furnish us a compound adhering to the hard and fast formulae set forth. In the majority of cases, the beryllium oxide content of the mineral is between about 9% and 11% BeO. In addition to Al_2O_3 and SiO_2, FeO or Fe_2O_3 are present. Frequently, smaller amounts of ZrO_2, Nb_2O_3, CaO, MgO and MnO_2 are present.

Pyrognostics, etc. Before blowpipe alone, unchanged or, if clear, becomes milky white and clouded; at a high temperature the edges are rounded, and ultimately a vesicular scoria is formed. Fusibility 5.5, but somewhat lower for beryls rich in alkalies. Glass with borax, clear and colorless for beryl, a fine green for emerald. Unacted upon by acids.

Differences. Characterized by its green or greenish-blue color, glassy luster and hexagonal form; rarely massive, then easily mistaken for quartz. Distinguished from apatite by its hardness, not being scratched by a knife, also harder than green tourmaline; from chrysoberyl by its form; from euclase and topaz by its imperfect cleavage.

Artificial. Crystals of beryl have been produced artificially by fusing a mixture of silica, alumina and glucina with boric oxide as a flux.

BERYLLIUM MINERALS

In addition to Beryl

Chrysoberyl, a beryllium-aluminum oxide of the composition $BeO.Al_2O_3$ (80.2 per cent Al_2O_3, 19.8 per cent BeO).

Phenakite, a beryllium orthosilicate of the composition $2BeO.SiO_2$ (54.45 per cent SiO_2, 45.55 per cent BeO).

Leucophane, a complex silicate of the composition $NaF.3BeO.$-$3CaO.5SiO_2$ with 10.3 per cent BeO.

Meliphanite, a complex silicate, somewhat similar to leucophane, of the composition $NaF.2BeO.2CaO.3SiO_2$ with 13.1 per cent BeO.

Helvite, a complex silicate of the composition (Mn, Fe) S.3(Be,-Mn, Fe)$_2$ SiO_4, with about 13.5 per cent BeO.

Euclase, a beryllium-aluminum silicate of the composition $2BeO.$-$2SiO_2.Al_2O_3H_2O$ (41.3 per cent SiO_2, 35.2 per cent Al_2O3, 17.3 per cent BeO, 6.2 per cent H_2O).

Gadolinite, a complex silicate of beryllium, iron and yttrium, of the composition $2BeO.FeO.2Y_2O_3.2SiO_2$ (23.9 per cent SiO_2, 51.8 per cent Y_2O_3, 14.3 per cent FeO, 10 per cent BeO).

Beryllonite, a sodium-beryllium phosphate of the composition $Na_3PO_4Be_3P_2O_8$ (55.9 per cent P_2O_5, 19.7 per cent BeO, 24.4 per cent Na_2O).

Herderite, a fluophosphate of calcium and beryllium of the composition (CaF) BePO (43.8 per cent P_2O_3, 15.4 per cent BeO, 34.6 per cent CaO, 5.9 per cent F).

Bertrandite, a beryllium silicate of the composition $4BeO.2SiO_2.$-H_2O (50.3 per cent SiO_2, 42.1 per cent BeO, 7.6 per cent H_2O).

Danalite, a complex mineral of the composition $(Be,Fe,Zn,Mn)_7$-$Si_3O_{12}S$ with about 14 per cent BeO.

Eudidymite, a beryllium-sodium silicate of the composition $H_2O.Na_2O.2BeO.6SiO_2$ (73.4 per cent SiO_2, 10.2 per cent BeO, 12.7 per cent Na_2O, 3.7 per cent H_2O).

Hambergite, a beryllium borate of the composition $4BeO.B_2O_3H_2O$ (53.25 per cent BeO, 36.72 per cent B_2O_3, 10.03 per cent H_2O).

Trimerite, a complex silicate of the composition $(Mn,Ca)_2SiO_4.Be_2SiO_4$ with 16.6 per cent BeO.

Bromellite, a beryllium oxide of the composition BeO.

Milarite, a complex silicate of the composition $K_2O.4CaO.4BeO.Al_2O_3.24SiO_2.H_2O$.

Barylite, a beryllium barium silicate of the composition $Be_2BaSi_2O_7$.

Kolbeckite, a hydrous silicophosphate of beryllium.

None of these minerals have been found in California with the exception of chrysoberyl, the occurrence of which is doubtful.

QUALITATIVE ANALYSIS

Detection. There are no satisfactory blowpipe reactions for beryllium, and tests must be made, therefore in the wet way, which requires some skill in manipulation.

a. If the mineral is a silicate, it may be decomposed readily by fusion with sodium carbonate and then dissolved. For a test, mix a scant ivory spoonful of the finely powdered silicate with 3 parts of sodium carbonate, make into a paste with a drop of water and then take up a portion of the material on a loop on platinum wire and fuse before the blowpipe. Make two or three beads, if necessary, rather than attempt to fuse all of the material at once. In almost all cases there results after fusion an opaque mass, the presence of various oxides contained in the mineral, mixed with the sodium silicate and excess of sodium carbonate, preventing the formation of a clear glass. The several beads, after removal from the platinum wire, are pulverized in a mortar, transferred to a test-tube, treated with about 1 cc. of water and an equal volume of nitric acid, and evaporated to dryness, being careful toward the end of the operation not to allow the tube to become very hot. After cooling, moisten the contents of the tube with about 3 cc. of hydrochloric acid, boil for a few seconds, so as to decompose any basic salts formed during the evaporation, then add 5 cc. of water, heat to boiling, and remove the insoluble silica by filtering. Then heat the filtrate from the silica to boiling, and precipitate the beryllium with ammonia, which will also cause precipitation of iron, aluminum, and possibly other elements, if present. Ammonia precipitates beryllium hydroxide, which resembles aluminum hydroxide in appearance. This is filtered and washed well with water, transferred together with the paper to some vessel, and warmed with dilute hydrochloric acid in order to dissolve it. The paper is filtered off, and the filtrate evaporated carefully (best in a casserole) until only a drop or two of the acid is left. After cooling, a few drops of water are added to obtain everything in solution, and then a little potassium hydroxide solution, a drop at a time, and just sufficient to dissolve the precipitate of beryllium hydroxide which forms at first. The solution is then diluted with cold water to a volume of at least 50 cc., any precipitate of ferric hydroxide or other material filtered off, and the filtrate boiled for a short time, when, if beryllium is present, a precipitate of beryllium hydroxide will appear.

b. If the mineral is a phosphate, special treatment is needed. The powdered mineral is dissolved in hydrochloric acid (after fusion

with sodium carbonate, if necessary); when cold, ammonia is added until a permanent precipitate forms, and then hydrochloric acid, a drop at a time, until the solution becomes clear. To the now nearly neutral, cold, and not too concentrated solution, sodium acetate is added, and the precipitated beryllium phosphate, which may also contain ferric and aluminum phosphates, is filtered and washed. The precipitate is next ignited in a crucible until the carbon of the paper is destroyed, and is then fused in platinum with sodium carbonate, by which treatment sodium phosphate and beryllium oxide are formed. The fusion is then treated with hot water to dissolve the sodium phosphate, the beryllium oxide is collected on a filter-paper and washed, and it is afterwards dissolved in hydrochloric acid and tested with potassium hydroxide, as described under *a*. If it is known that the alkali-earth metals are absent, the mineral may be fused directly with sodium carbonate, and treated like the above sodium carbonate fusion.

CALIFORNIAN LOCALITIES

Fresno County: Beryl was reported to be associated with feldspar, 5 miles northeast of Trimmer.

Inyo County: Blue crystals of beryl are reported to occur in quartz, in narrow pegmatite veins cutting granite, 6 miles south-southeast of Lone Pine.

Riverside County: Fine yellow and green beryl was found at Coahuila and rose beryl occurred near Hemet. Green and blue beryl crystals about half an inch long have been found in a pegmatite dike about 200 yards west of the Jensen limestone quarry, near Crestmore.

San Diego County: Yellow, green, and blue crystals of beryl occur in the Palomar Mountains, 9 miles southeast of Pala. Rose, yellow, and green beryl crystals occur at Pala, Rincon and Mesa Grande. Pink beryl occurs at the Katrina mine, Pala and at Oak Grove. Fine, large crystals of beryl have come from Aguanga Mountain. Golden and aquamarine beryl occurred at the Esmeralda mine. Fine crystals of beryl were found at the Surprise, A B C, Hercules, and Lookout mines, Ramona.

Tuolumne County: Beryl has been reported from near Jamestown.

GENERAL INFORMATION

History. In 1797 Haüy, a mineralogist, found that the minerals beryl and emerald have the same physical structure, hardness, specific gravity, and at his suggestion the French chemist Vauquelin proved that these minerals are identical chemically. In making the analysis he recognized an unknown earth in the mineral beryl, and called that body "glucine" (meaning sweet earth), on account of the sweet taste peculiar to its salts. This appellation for the base and the term "glucinum" for the element, derived therefrom, have been preserved in France and England, but not in the United States, where the name beryllium instead of glucinum is generally accepted. In 1828 Woehler and Bussy succeeded first in isolating metallic beryllium by fusing the chloride with potassium in a platinum crucible, though the product thus obtained was pulverulent and impure. A few years later Becquerel produced the metal in purer condition by electrolyzing a solution of

the chloride, and in 1854 Debray obtained pure beryllium by conducting the vapors of the chloride over fused sodium in an atmosphere of hydrogen. The metal produced by Debray was white in appearance, and could be forged and rolled into sheets like gold.

Atterberg and Nilson and Pettersson, in the years between 1873 and 1885, made large additions to the chemistry of beryllium, and during these years a long, earnest, and interesting discussion was carried on by Nilson and Pettersson, Humpidge, Reynolds, Hartley, Lothar Meyer, Brauner, and others regarding the valency of beryllium and its place in the periodic system. The discussion has continued up to the present day, but was in reality settled when Nilson and Pettersson determined the vapor density of the chloride, and Humpidge showed that at high temperatures the specific heat of beryllium approached very closely to normal. Krüss and Moraht made a redetermination of the atomic weight in 1890, and between the years 1895 and 1899 Lebeau published an important series of articles which are summed up by him in one of the very best articles on beryllium and its compounds. Urbain and Lacombe discovered the remarkable basic salts of the acetic acid series and Parsons redetermined the atomic weight by new methods and studied many compounds, especially the so-called basic salts of some of the earlier writers.

In 1913 Fichter and his pupils prepared beryllium in sufficient quantity to study its properties, employing the method of M. Lebeau, and obtained a 98 per cent pure metal.

In 1916 Oesterheld published an important experiment. He studied more particularly the equilibrium diagrams of the alloys beryllium-iron, beryllium-aluminum, beryllium-copper, and beryllium-silver.

In 1921 Stock and Goldschmidt, in Germany, with the cooperation of Priess and Praetorius, obtained metallic beryllium for the first time in the form of large buttons, directly from a fused electrolyte.

Chemistry and Commercial Points. Beryllium of the atomic weight 9.02 and specific gravity 1.85 is a white, ductile metal, whose fusing point lies near 1350° C. It melts in the outer blowpipe flame, without igniting like zinc or iron, and does not burn, when heated in an atmosphere of oxygen, but covers itself with a layer of oxide, which appears to prevent further change. If heated, however, in very finely divided form in the air, it burns with an extremely bright light. The metal shows but very little affinity for sulphur, but combines, when heated, directly with chlorine and iodine. It unites readily with silicon, forming a hard, brittle substance, which takes a high polish. Beryllium does not decompose water at a boiling heat, or even when heated to whiteness. Sulphuric and hydrochloric acids as well as potassium and sodium hydroxides dissolve it with evolution of hydrogen. Nitric acid does not affect it at ordinary temperatures, but dissolves it slowly at the boiling heat.

Observations. Beryl is obtained from pegmatite veins in granitic rocks from various parts of the world and is usually recovered as a by-product of such minerals as feldspar and mica. It has commanded a price of $30 a ton at the mines; at this price ample beryl has been provided for the world's use. Since the European blockade, consider-

able quantities of Brazilian and Argentinian beryl have been offered to United States consumers.

Beryllium probably is not a particularly rare element. It is often considered as being about 10 times as abundant in nature as tin, which commonly has sold for 50 cents or less per pound. Beryllium, even alloyed, sells for $23 per pound.

This relatively high cost is due largely to the fact that the only ore seems to be beryl, a mineral that contains only about 4 per cent beryllium and has been found in commercially acceptable form only in some pegmatites. These, in turn, do not constitute more than 1 per cent of the earth's crust and seldom include more than 1 per cent beryl. Inasmuch as beryl is distributed erratically and sparsely, reserves are difficult to estimate, and mining tends to be costly unless other minerals can be produced at the same time and thus bear part of the expense. When pegmatites weather, many of their constituent minerals remain unattacked, and the heavier—like monazite and tin and tungsten minerals—may be concentrated in the residual mantle or transported to form placer deposits. Beryl, however, is as alterable as the feldspars. Although the beryllium content may reappear as a constituent of other secondary minerals, such as bertrandite, herderite, or beryllonite, none of these minerals is heavy enough to be separated by the sorting action of streams or other natural concentrating agencies, and consequently the beryllium is too diluted to be recovered on a commercial basis.

In the light of the above statement concerning the sparse occurrence of beryl, it may seem paradoxical to note that at present more ore is offered than consumers can use. Nevertheless, the industry will not be justified in developing new uses for beryllium or undertaking any greater expansion of the industry until regular and adequate supplies of ore are assured. Demand undoubtedly would expand rapidly if the price were cut to even $10 a pound, and at about $5 the steel industry might absorb great quantities. Although the metallurgy of beryllium is much more complex than that of tin, processes are available whereby the metal or its alloys could be produced at only a fraction of their cost at present small-scale operating rates.

Domestic requirements of beryl in 1937 were supplied from the South Dakota Black Hills, Colorado, British India, and South America. Figures on domestic production are not available, but imports were reported as 182 tons, valued at $8,031, and in 1936 they were 162 tons valued at $6,681. Probably the best-known Indian deposit is at Bellore, Madras; but beryl occurs also at Kdarma in Bihar, at Padyur near Kangayan in the Coimbatore district, and at one or two places in the Toda Hills of Rajputana. Another part of the British Empire, the Union of South Africa, is considered one of the largest reserve sources of beryl supply. Important emerald mines in the Murchison Range near Leydsdorp in Northern Transvaal contain recoverable beryl of nongem quality in some quantity. Material carrying over 5 per cent beryl is reported as having been mined in Little Namaqualand, Cape Province, in the neighborhood of Jackals Water near Stinkopf. The reserves are said to amount to hundreds of thousands of tons of beryl. Samples of the beryl averaged 10.35 per cent BeO. Pegmatites elsewhere in Africa carry beryl, and further supplies can be

obtained in Canada, Australia, South America, and probably also in Europe. Consumers hope that substantially more than 10,000 tons of beryl a year could be produced from sources already investigated and that somewhere in the world may be found a large low-grade deposit that may be worked by mass production methods. Laboratory tests indicate that there will be no difficulty in concentrating beryl by froth flotation when and if sufficiently large uniform deposits are located and demand expands.

Domestic production of beryllium increased in 1937, but the industry is quite small, as is indicated by an estimated consumption of somewhat less than 500 tons of beryl in the United States and probably less than 500 tons in all other countries. These figures, only a careful guess, include in each instance an allowance of around 100 tons for beryl used directly in the ceramic industry. Some quantities of beryllium oxide and other compounds likewise are used in glass and ceramic glazes, as well as in super-refractories and as high-duty abrasives. After allowance for these further deductions, the production of metallic beryllium in alloys in 1937 probably did not exceed 15,000 pounds.

Beryllium master alloys continue to be produced in the United States, principally by two companies—the Brush Beryllium Corporation and the Beryllium Corporation of Pennsylvania. At least two other companies have produced the metal or its alloys recently, and several others have been actively interested in starting production. One of these prospective enterprises is reported to be backed by an important New York banking firm. Next to the United States, Germany is the main source of beryllium products, although the little-publicized Italian industry seems to be relatively important, and experimental production has been begun or contemplated in a number of European countries. It is rumored, too, that Japan is using 1,500 kg of beryllium annually and expects soon to undertake production at a rate of 1,000 kg a year.

Late in 1936 the price of beryllium-copper master alloy was reduced from $30 to $23 per pound of beryllium content, but inasmuch as the main outlet is in finished forms carrying only about 2.25 per cent beryllium, there was no reduction in prices to ultimate consumers. Sales of beryllium-copper were reported as having gained 60 per cent in 1937 after having doubled in 1936, but these gains were due mainly to more selling pressure and growing recognition of the excellent properties of the alloy. Notwithstanding the high prices at which it must be sold at present—principally because of the small volume of business and relatively large expenditures for research and general overhead—beryllium-copper is still an economical material for numerous special purposes, especially where high fatigue values, or wear and corrosion resistance, combined with good electrical conductivity, are needed. Interest has been renewed in beryllium-aluminum alloys, and a master alloy with aluminum (or other base metals) that costs $50 per pound of contained beryllium is now available. Alloys with nickel are obtainable already from Germany, and in the near future may be supplied domestically.

Notwithstanding the great interest displayed by several chemical-manufacturing companies, inventors, and investors and the various

rumors of new enterprises engaged in producing beryllium on a more or less large scale, the world output of beryl probably still fails to exceed 750 tons a year. In the United States the commercial supply of the metal and its commercial compounds continues to come entirely from two companies—the Beryllium Corporation of Pennsylvania (Andrew Gahagan, president), Temple (near Reading), Pa.; and the Brush Beryllium Corporation (C. B. Sawyer, president), 3714 Chester Avenue, Cleveland, Ohio.

The Beryllium Corporation of Pennsylvania, which has a cooperative arrangement with Siemens & Halske, the leading German beryllium producer, for the exchange of information and patents, recently has completed a fabricating plant at Reading, Pa., the first to be designed especially for rolling and drawing beryllium alloys. In 1935 this company transferred its plant activities from Michigan to Pennsylvania and engaged in the production of nonsparking tools and other beryllium-copper castings but continued to sell a major portion of its output in the form of master alloys to the American Brass Co. and the Riverside Metal Co. for remelting and fabrication. Under the new set-up the Beryllium Corporation of Pennsylvania, however, will be in a position to supply all kinds of beryllium and copper products, including sheet, strips, wire, and tubing as well as castings, finished alloy, ingots, and master alloys. Inasmuch as it also will produce sheet bars and billets from the molten alloys, the new policy may result in other fabricators undertaking the manufacture of some of these products, thereby broadening the market. The equipment of the new fabricating plant is much heavier than that hitherto employed for forming the hardest copper alloys, and all operations from the purchase of the ore to the marketing of the products to the ultimate consumer will be under the technical control of the one company. The capacity of the plant exceeds anticipated needs at present and can be increased readily as required.

Price has always been a deterrent to more rapid expansion in the use of beryllium. The price of the beryllium content of master alloys was reduced a year ago from $30 to $23 a pound of Be content, but the base price of finished beryllium-copper products (about 2.25 per cent Be) had to be increased from 89 cents to $1.12 a pound owing to the difficulties of fabrication. To meet the demand for a material intermediate in physical properties between standard beryllium copper and phosphor bronze an entirely new group of alloys is being offered. One series contains 0.4% to 0.5% Be, 2% or 3% cobalt, and the rest copper; another is similar, except that chromium replaces cobalt; and still another comprises beryllium-nickel alloys that heretofore have not been manufactured commercially in the United States.

Possibly the most significant development in the beryllium industry during 1938 was the interest in the wider use of the element in munitions, more specifically in vital parts of airplane engines. Of interest also is the employment of beryllium or, better, an 80-per cent ferroberyllium, for cementing steel. Beryllium dissolves readily in gamma iron, and by a suitable technique a maximum penetration of 20 to 25 millimeters can be obtained—with the case-hardened surface showing a hardness of over 1,000 Brinell. Beryllium oxide films may be used to prevent tarnish on silver, although preliminary reports indi-

cate that aluminum may be as satisfactory, and of course it is much cheaper.

Among alloys in practical use are nickel with 2.5 per cent Be, which hardens to 600 Brinell after quenching from 1,100° C. and drawing at 400° to 500° C., and 18-carat gold, which beryllium hardens to 300 Brinell. Steel with 36 per pent nickel and 1 per cent beryllium is rustless and machinable, but like Invar it does not expand or contract when heated. Beryllium forms a eutectic with iron at 9.2 per cent Be and 1,150°C., and this alloy can be refined in grain by heat treatment. Tin-beryllium alloys containing 0.2 per cent Be are 20 per cent less ductile than pure tin but are slightly harder and have improved bending strength. When the proportion of beryllium is increased primary crystals of beryllium form in a ground mass containing only a few tenths of 1 per cent Be. Beryllium additions to aluminum-magnesium alloys prevent loss of Mg by oxidation during melting, prevent surface defects on castings, and inhibit discoloration during heat treatment. They tend, likewise, to promote coarser structure, increasing the time of heat treatment and decreasing mechanical properties, but this disadvantage is neutralized by adding a little titanium. Only 0.02 per cent Be is required in these alloys, and it is obtained from a master alloy containing about 90 per cent Be and 7% to 12% Mg made by adding the double fluoride of these metals to the surface of an aluminum bath at about 1,350° F.

The search for uses of other alloys and even of the metal itself continues unabated, but practical sales effort in the United States hitherto has been focused mainly on expanding the demand for beryllium-hardened copper in electrical devices and small machines. This alloy, which is soft and ductile before heat treatment and easily fabricated, can be made hard and high in elastic properties by simple one-stage treatment. Its exceptional resistance to fatigue and good electrical conductivity make it a valuable material for flat and coil springs. To illustrate the remarkable life of beryllium copper, one manufacturer reports that vibrator springs, heavily stressed 230 times per second and subjected to severe temperature changes, exhibited no measurable alteration in physical or electrical performance after 2 billion vibrations.

About 1 ton of beryllium worth 3,000 francs per kilogram (about $40 a pound) is now being produced annually in France. A leading electrical company makes it by electrolysis in a fluoride bath from beryl obtained near Limoges and Autun, supplemented by supplies from Madagascar. Italy, Japan, and possibly other countries are credited with small or occasional outputs, but the United States and Germany produce the bulk of the world beryllium supply in the form of alloys.

Beryl occurrences have been reported in various parts of the United States, but few mines outside of the Black Hills, S. Dak., have produced as much as a carload, and most of the domestic production has been obtained as a by-product of feldspar, lithium, or rare-metal ore mining. No statistics of domestic output are available. A substantial part of domestic consumption in recent years has been supplied by imports, which in 1938 amounted to 146 short tons valued

at $5,990, all from British India and Argentina excepting a 10-ton lot from the Union of South Africa.

The most important deposit of beryl in U. S. S. R. which also yields emeralds, is some 70 kilometers from Sverdlovak, in the Urals; the beryl is associated with talc, mica, chlorite, and actinolite schists. Hungarian bauxites are found to contain only 0.005 to 0.01 per cent BeO, far too little to encourage hopes of industrial recovery of the beryllium.

More beryl is being offered than can be consumed at present demand levels, and the price is still quotable at $30 a ton f.o.b. mines for 10% to 12% ore and up to $55 a ton delivered at consuming plants for higher grades. These figures correspond to an ore cost of approximately $1.25 a pound of recovered beryllium metal, which could be increased substantially if necessary to stimulate mining and still permit the metal to be made at well under $5 a pound. Many people have labored under the delusion that beryllium can not be sold at less than $23 a pound, even in its master alloys, because conversion costs are excessively high; this is not true. Suitable methods of reducing the metal from its ores have already been worked out, and they are not inherently expensive. On the other hand, very large sums have been spent upon research, educational campaigns, patents, and other expenses incident to the development of a new metal, and the burden of these expenses has had to be borne by a relatively small volume of actual sales. It is confidently asserted that $10 a pound is an early possibility, provided the scale of operations can be substantially increased. It is somewhat less certain what can be done about lowering prices to the ultimate consumer because less is known as to the cost of manipulating the alloys; however, a base price of 75 cents for the standard, 2.25-per-cent copper alloy is mentioned tentatively as being in sight, and eventual reduction to not more than double the cost of phosphor bronze seems likely.

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STRATEGIC MINERALS INVESTIGATIONS PROCEDURE FOLLOWED BY THE U. S. BUREAU OF MINES[1]

By John W. Finch[2]

WHAT IS AUTHORIZED

The Secretary of the Interior acting through the Bureau of Mines and the Geological Survey is authorized by the Strategic Materials Act (public No. 117—76th Cong., Chapter 190, 1st Sess.) to make investigations concerning essential minerals of which the quantities or grades obtainable from known domestic sources are inadequate.

The Bureau of Mines, in carrying out its part of this program, may investigate deposits of such minerals in whatever manner may be necessary, in order to determine (1) the extent and quality of the ore, (2) the most suitable method of mining and beneficiating it, and (3) the cost at which it may be produced. The essential objective in doing these things is to determine where and how supplies of minerals and metals of which domestic production is usually inadequate might be obtained in a national emergency, even though at higher cost than usual.

The Geological Survey extends or renews its studies of mineralized areas, including those selected by the Bureau of Mines for investigation, recommends deposits of which it already has knowledge, and advises the Bureau of Mines with respect to all geological aspects of the investigations.

The Procurement Division of the Treasury Department, Washington, D. C., is the agency authorized to make all purchases of minerals, metals, and other strategic materials required by the Government. Those who desire to sell minerals or metals to the Government should therefore apply directly to the Procurement Division, not to the Bureau of Mines. The Bureau has nothing whatever to do with the part of the Act that authorizes purchase of minerals or metals to be warehoused or stockpiled as reserves for use only in a national emergency.

WHAT IS NOT AUTHORIZED

The Bureau of Mines is not authorized to purchase mining properties, to operate them, or to render financial assistance to prospectors, owners, or operators of mines; and no compensation or gratuity is paid for information leading to the discovery of mineral deposits. The Bureau does not make assays or analyses of ores to save the public the expense of having them made by commercial assayers or chemists, or examine mines upon request to save their owners the cost of examination by mining engineers. Neither the Bureau nor any employee is authorized to make any request of owners or operators of properties to perform any work or incur any expense for the benefit of the Government in expectation of reimbursement or of recovery of

[1] Reprinted from U. S. Bureau of Mines Information Circular 7097.
[2] Director, U. S. Bureau of Mines.

damages therefor, unless the request is evidenced by a contract, signed by the Director and the other party concerned, specifying what is to be done and its cost.

METALS SOUGHT

In its Strategic Minerals Investigations the Bureau of Mines is chiefly concerned at present with seven metals, all of which have been designated as of strategic importance by the Secretaries of War, the Navy, and the Interior upon advice of the Army and Navy Munitions Board. They are: Antimony, chromium, manganese (*ferro-grade*), mercury, nickel, tin and tungsten. Investigations of other metals and minerals whose strategic importance is less pronounced must be deferred to a later year of the Strategic Minerals Program.

MANGANESE

In explanation of the term "ferro-grade" applied to manganese, it should be stated that manganese ore comprises four very different raw materials, determined by grade and quality, as follows:

(1) Exceptionally high-grade manganese ore characterized by a high content of MnO_2 is used in making batteries. It commands the highest unit price and is known as battery ore.

(2) At the other extreme is manganiferous iron ore, usually containing 10 per cent or less manganese; it is used for making manganiferous pig iron. The domestic supply of such ore is so abundant that the manganese it contains is usually paid for as if it were iron.

Between these two extremes are the ores, low in iron, that are suitable for making ferromanganese and those high in iron used for making spiegeleisen, although some of it also is used for making pig iron.

(3) For making ferromanganese the ore usually contains at least 45 per cent manganese but averages 48 per cent; and the ratio of manganese to iron is not less than 7 to 1, though it usually is 8 to 1, while there must be low silica (ranging from 7 to 10 per cent) and very low phosphorus (ranging from 0.12 to 0.2 per cent). Only manganese ore of this character has been designated as a strategic mineral because domestic production is inadequate.

(4) Ore in which the manganese-iron ratio is too low for making ferromanganese can be used for making spiegeleisen. Of such manganese ores, high in iron, there is no deficiency, and a relatively low price is paid for the manganese they contain. Although an excess of silica often can be remedied by gravity concentration, iron is difficult to remove by that means because the specific gravities of iron and manganese oxides are so nearly the same.

CHROMIUM

Chromite ($Cr_2O_3.FeO$), the commercial source of chromium, has three major uses: (1) For making chromium-steel alloys, (2) for making refractories, and (3) for making chemicals. The first two account in nearly equal degree for over three-fourths of the consumption of chromium. Excess of iron is detrimental in both of these

uses. A minimum chromium-iron ratio of about 3 to 1 is required for metallurgical uses and high iron renders refractories less resistant to heat and corrosion. The usual requirement as to grade is Cr_2O_3 48 per cent, maximum sulfur 0.5 per cent, and maximum phosphorus, 0.2 per cent. Silica usually is limited to 5 per cent. In the United States there is much chromite containing high iron, but there is a dearth of known deposits of high-grade chromite.

BUREAU OF MINES INVITES INFORMATION

The Bureau of Mines welcomes statements of fact as to the nature and situation of deposits containing any of these seven metals. Especially welcome are facts that are specific as to deposits believed to contain the strategic metals in substantial amounts. Merely small showings of ore, however rich, are of less interest than large deposits appearing to contain considerable tonnage of metal, even though the ore may be so relatively low in grade that it would not usually be mined at a profit.

To assist in obtaining facts that will be most helpful to the Bureau a simple, brief form is available for the use of any who request it.

EXAMINATION OF PROPERTIES

Properties indicated by data available to the Bureau as of possible interest will be visited by its examining engineers to confirm and extend information in regard to them. As there are thousands of properties that should be seen eventually, it is necessary to route these engineers systematically to conserve time and minimize expense. Therefore it will not be practicable to make special examinations in response to solicitation. Neither will the examining engineers conduct regional searches to discover unknown deposits or to investigate formations as such, the latter being a function of the Geological Survey. They will be concerned chiefly with individual properties upon or within which, as shown by outcrops, mine workings, trenching or drill exploration, substantial deposits or ore are presumed to exist.

SELECTION OF PROPERTIES FOR EXPLORATORY PROJECTS

Selection of properties for the conduct of exploratory projects upon them will be made from those that appear from preliminary examination to promise most with respect to the national objective, without regard to their geographical situation. No allotments will be determined by State or other geographical boundaries, as this would defeat the purpose of the Act.

In general, properties likely to yield only small, rich ore bodies will not be selected, as the cost of exploration would be excessive in proportion to the tonnage of metal that might be derived from them. Preference will be given to properties whose ores appear to be subject to concentration into an acceptable product of which a large tonnage might be disclosed by systematic exploration, especially by drilling. With respect to such deposits there is no presumption that they should prove to be commercial in ordinary times. It is the scarcity of commercial deposits of these minerals that has caused them to be declared strategic. The hope is to find marginal and moderately submarginal

properties that may nevertheless yield substantial tonnages under circumstances in which the cost of production would not be of major importance.

CONDUCT OF PROJECTS

Available funds are only adequate to permit the conduct of about eight projects at a time. The consent of owners of the properties selected must be obtained before work upon them is begun. No stipulation as to the work to be done is made, and no work is undertaken by request or for the purpose of benefitting the owner. Neither will any report be supplied for use in promotion. The only undertaking by the Bureau of Mines is that of providing a copy of any assay charts made in order that the owner may be informed as to values and widths of ore disclosed by the investigations.

All sampling on projects is done with extreme care, large samples being shipped to a metallurgical laboratory of the Bureau for reduction, analysis, and the conduct of beneficiation tests. If commercial ore is found it is the privilege of the owner to mine it, as no reservations are made to retain any control of property by the Government. Neither is the owner of a property investigated subject to any charge for any benefit he may happen to receive, although he is expected to grant free access to all parts of the property for purposes of sampling and to permit the use by the Bureau during the conduct of its investigations of any equipment he may have available on the property, not essential to his own operations.

OBJECTIVE OF INVESTIGATIONS

The objective of these investigations is unusual, in that they are not concerned primarily with the commercial possibilities of the deposits; a reorientation from the normal approach to mineral exploration is thus required. It is not to be supposed that large deposits of commercial promise have been overlooked by private enterprise; but private industry has no incentive to develop submarginal or even marginal ores. It is known that some large deposits of this character have been explored only superficially, and it is probable that there are many others. Deliberate investigation of these deposits, while time permits thorough exploration and the development of methods best suited to their beneficiation and processing, will save much confusion, inefficiency, and waste of time and money in the actual event of a national emergency.

In some circumstances even negative results of investigations would prove of great value because definite proof that specific deposits could not be relied upon as sources of supply at any price would aid in determining what should be stocked in advance of an emergency and also to show what research for the development of substitutes is necessary. Insistence of owners that certain deposits contain large resources, in spite of virtual proof to the contrary, has created in some minds a false sense of security regarding emergency protection. Some properties of this kind wll doubtless require investigation now in order that in an actual emergency the facts in regard to them may be well understood.

In effect, the Government desires to know definitely its natural resources of the several strategic minerals—the tonnage, grade, quality and rate at which production can be maintained—as well as the cost of mining and beneficiating the minerals to provide a usable product. Such information is obviously necessary for intelligent planning of national defense and meeting industrial needs if our usual supplies of imported minerals should be cut off through interruption of sea-borne trade.

ADMINISTRATIVE

WALTER W. BRADLEY, State Mineralogist

Personnel

There have been no changes in personnel to be noted during the past three months.

New Publications

CALIFORNIA JOURNAL OF MINES AND GEOLOGY, April 1939, being Chapter 2 of State Mineralogist's Report XXXV. This chapter contains: "Mineral Resources of Shasta County," accompanied by a map showing the locations of the principal mineral deposits; also a special article on "The Public's Interest in Mine Taxation"; also accessions to the Mineral Exhibit and to the Library of the Division of Mines.

CALIFORNIA JOURNAL OF MINES AND GEOLOGY, July 1939, being Chapter 3 of State Mineralogist's Report XXXV. This chapter contains: "Under the Geologic Branch: Tertiary Formations of Northern Sacramento Valley," accompanied by a geologic map; "Geology and Oil Possibilities of Caliente Range, Cuyama Valley, and Carrizo Plain," accompanied by a geologic map and stratigraphic columns; "Bibliography of the Geology and Mineral Resources of California for the year 1937" (supplementing Bulletins 104 and 115); "The Giant Goose Lake Meteorite." Under Special Articles: "Costs of Trucking and Packing Ore in Western Gold-Mining Districts"; "Strategic Minerals Act"; "Assessment Work on Mining Claims for 1938-1939"; New Mining Legislation, 1939. Also a summary of the Mineral Production of California for the year 1938; accessions to the Mineral Exhibit and the Library; also notes on "Corrections and Additions to Bulletin 113."

COMMERCIAL MINERAL NOTES (Nos. 199-201 incl.) November, December, 1939, and January 1940, respectively. These 'Notes' contain the lists of 'mineral deposits wanted' and 'mineral deposits for sale', issued in the form of a mimeographed sheet monthly. It is mailed free to those on the mailing list for 'California Journal of Mines and Geology.' As an evidence of the interest in mines and mineral resources now showing considerable activity, this mimeographed 'sheet' has had to be expanded to five pages in recent months.

Mail and Files

The Division of Mines maintains, in addition to its correspondence files and the library, a mine file which includes original reports on the various mines and mineral properties of all kinds in California.

During each quarterly period there are several thousand letters received and answered at the San Francisco office alone, covering almost every phase of prospecting, mining and developing mineral deposits, reduction problems, marketing of refined products and mining law. In addition to this, hundreds of oral questions are answered daily, both at the main office and the district offices, for the many inquirers who come in for personal interviews and to consult the files and library.

MINERALS AND STATISTICS

Statistics, Museum

Henry H. Symons, Statistician and Curator

STATISTICS

CALIFORNIA MINERAL PRODUCTION FOR 1939

The total value of the mineral production of California for the year 1939, just closed, is conservatively estimated by the Statistical Section as $356,095,000. This is partly detailed in the tabulation below, but as there are more than 55 mineral substances on California's commercial list, figures on the most important items only are available at this early date. The production report forms are being mailed to the operators in all mineral lines, and the detailed and completed report will be compiled and published later.

The estimated total of $356,095,000 is a decrease of approximately $24,350,000 from the 1938 total value. The principal increases in values over those of the previous year were shown by the metals gold, copper, quicksilver, and silver; the industrial group and saline group. Important minerals to register decreased values were petroleum, natural gas, miscellaneous stone, cement, and brick.

Petroleum output showed a decrease in both amount and value from that of the previous year of about 10 per cent. The estimated quantity was 224,376,000 barrels, a decrease of about 25,000,000 barrels. There was little or no change in the prices paid to producers by the refineries. There was a decrease of about 2 per cent from 1938 in the amount and value of natural gas utilized.

Receipts of bullion at the mint and smelters showed an increased output of gold of some 95,000 fine ozs. Thus 1939 had the highest annual gold value since 1856, and the largest yield in fine ounces since 1862; also the largest annual lode output in both amount and value in the history of mining in the State. The silver and quicksilver yield each had a total value over the million-dollar mark. The output of silver, copper, and quicksilver each showed an increase over that of 1938.

Of the structural group, these materials as a whole showed a decreased production and value from that of the previous year. Although building permits in 51 principal cities of the State increased approximately 8.6 per cent, large public construction was less than in 1938 as many larger projects were completed in that year. Conditions indicate the miscellaneous industrial and saline groups should show increases in their total value over 1938.

The estimated values and quantities for 1939 are as follows:

$ 49,210,000	(1,406,000 fine ozs.) gold.
1,773,000	(2,613,000 fine ozs.) silver.
875,000	(8,410,000 lbs.) copper.
43,000	(860,000 lbs.) lead.
1,140,000	(11,500 flasks) quicksilver.
970,000	Other metals including chromite, iron ore, platinum, tungsten ore, zinc, and others.
231,109,000	(224,376,000 bbls.) petroleum.
22,015,000	(328,582,000 M. cu. ft.) natural gas.
14,960,000	(10,681,000 bbls.) cement.
10,500,000	crushed rock, sand and gravel.
2,500,000	brick and hollow building tile.
1,200,000	other structural materials, including bituminous rock, granite, magnesite, marble, sandstone, slate, etc.
5,300,000	miscellaneous industrial materials.
14,500,000	salines, including borates, potash, iodine, salt, soda, and others.
$356,095,000	Total.

MUSEUM

The Museum of the State Division of Mines possesses an exceptionally fine collection of rocks and minerals of both economic and academic value. It ranks among the first five of such collections in North America and contains not only specimens of most of the known minerals found in California, but much valuable and interesting material from other states and foreign countries as well.

The exhibit is daily visited by engineers, students, business men, and prospectors as well as tourists and mere sightseers. Besides its practical use in the economic development of California's mineral resources, the collection is a most valuable educational asset to the state and to San Francisco.

Mineral specimens suitable for exhibit purposes are solicited, and their donation will be appreciated by the State Division of Mines as well as by those who utilize the facilities of the collection.

Among the specimens received recently and catalogued for the Museum are the following:

20964 PYRITE Crystals in soapstone. From the northeast corner of Del Norte County, California.
Donor: A. W. Porter. November, 1939.

20965 Vesicular BASALT (both black and red). From Truckee River Canyon, Nevada County, California.
Donor: Walter W. Bradley. November, 1939.

20966 HALOTRICHITE—$FeSO_4.Al_2(SO_4)$ $22H_2O$—a hydrous iron-aluminum sulphate. From Leviathan Sulphur Mine, near Markleeville, Alpine County, California.
Donor: Calpine Corp. November, 1939.

20967 IRON-COPPER CHALCANTHITE—$FeO.CuO.2SO_3.10H_2O$—a hydrous iron-copper sulphate. From the Leviathan Sulphur Mine, near Markleeville, Alpine County, California.
Donor: Calpine Corp. November, 1939.

20968 CINNABAR in altered granitic rock and aplite. From Cuddeback Quicksilver Mine near Tehachapi, Kern County, California.
Donor: Walabu Mining Co. November, 1939.

20969 Facsimile of the "WELCOME STRANGER" gold nugget found at Moliagul, Victoria, Australia, on February 5, 1869. Weight, 2,516 ounces Troy; value, 9,553 pounds, or $46,428. This is the largest nugget of which there is authentic record.

20970 GOLD AND BLACK SAND (four small glass tubes) recovered by Peterson Pneumatic Jig from the Amo Placer Mine, near Oroville, Butte County, California.
1. Fine gold of less than 200-mesh.
2. Fine gold of 100-mesh.
3. Average size of gold flakes.
4. Black sand concentrate—value $1080 per ton.
Donor: Roy Hawley. December, 1939.

20971 PUMICE (one ground) Locality: About 11 miles northerly from Bagdad Station, San Bernardino County, California.
Donor: J. A. Chambless. December, 1939.

20972 JADE (Nephrite) From California.
Donor: F. J. Sperisen. December, 1939.

20973 SILICON, Si.
Donor: Charles B. Smith. January, 1940.

20974 BLACK SAND with free GOLD and PLATINUM and piece of gold (amalgam sponge). Locality: Beach at Fort Funston, San Francisco, California.
Donor: M. Hess. January, 1940.

20975 NORBERGITE—$Mg_2SiO_4.Mg(F,OH)_2$—a magnesium fluosilicate. Locality: Franklin, New Jersey.
Donor: James F. Morton. January, 1940.

20976 CHONDRODITE—$Mg_3(SiO_4)_2.(Mg(F,OH))$—a magnesium fluosilicate. Locality: Franklin, New Jersey.
Donor: James F. Morton. January, 1940.

20977 NATROLITE—$Na_2Al_2Si_3O_{10}.2H_2O$—a sodium-aluminum hydrous silicate. Locality: Paterson, New Jersey.
Donor: James F. Morton. January, 1940.

20978 PECTOLITE—$HNaCa_2(SiO_3)_2$—a calcium-sodium basic silicate. Locality: Paterson, New Jersey.
Donor: James F. Morton. January, 1940.

20979 TEPHROITE with ZINCITE and FRANKLINITE. Locality: Franklin, New Jersey.
Donor: James F. Morton. January, 1940.

20980 STILBITE—$H_4(Na_2Ca)Al_2Si_6O_{18}.4H_2O$—a hydrous sodium-calcium-aluminum silicate. Locality: Paterson, New Jersey.
Donor: James F. Morton. January, 1940.

20981 HANCOCKITE with microscopic crystals in vug, exceedingly rare. Locality: Franklin, New Jersey.
Donor: James F. Morton. January, 1940.

20982 PREHNITE—$H_2Ca_2Al_2(SiO_4)_3$—a hydrous calcium-aluminum silicate. Locality: Paterson, New Jersey. January, 1940.
Donor: James F. Morton. January, 1940.

20983 PREHNITE showing cavity once filled with Anhydrite. Locality: Paterson, New Jersey.
Donor: James F. Morton. January, 1940.

20984 APOPHYLLITE—$K_2O.8CaO.16SiO_2.16H_2O$—a hydrous potash-aluminum silicate of the Zeolite group. Locality: Paterson, New Jersey.
Donor: James F. Morton. January, 1940.

20985 ANALCITE—$NaAlSi_2O_6.H_2O$—a hydrous sodium-aluminum silicate. Locality: Paterson, New Jersey.
Donor: James F. Morton. January, 1940.

20986 CHABAZITE—$(Ca.Na)Al_2Si_4O_{12}.6H_2O$—a hydrous calcium-sodium-aluminum silicate. Locality: Paterson, New Yersey.
Donor: James F. Morton. January, 1940.

20987 HARDYSTONITE with Calcite, Franklinite, Willemite, etc. Locality: Franklin, New Jersey.
Donor: James F. Morton. January, 1940.

20988 DATOLITE—$Ca(BOH)SiO_4$—a basic calcium-boron orthosilicate. Locality: Paterson, New Jersey.
Donor: James F. Morton. January, 1940.

20989 BARITE—$BaSO_4$—barium sulphate. Locality: Paterson, New Jersey.
Donor: James F. Morton. January, 1940.

20990 CALCITE, a rare type, found only once and at first assumed to be Aragonite, on Prehnite. Locality: Paterson, New Jersey.
Donor: James F. Morton. January, 1940.

20991 HEULANDITE—$H_4CaAl(SiO_3)6.3H_2O$—a hydrous calcium-aluminum silicate. Locality: Paterson, New Jersey.
Donor: James F. Morton. January, 1940.

20992 THAUMASITE—$CaSiO_3.CaCO_3.CaSO_4.15H_2O$—a hydrous calcium silicate, carbonate, and sulphate. Locality: Paterson, New Jersey.
Donor: James F. Morton. January, 1940.

20993 GREENOCKITE—CdS—cadmium sulphide. Locality: Franklin, New Jersey.
Donor: James F. Morton. January, 1940.

20994 Native SILVER in FLUORITE. Locality: Mt. Patterson District, Mono County, California.
Donor: L. Dellamonica. January, 1940.

20995 MILL STONES made by a Chinese miner, John Sing, in about 1870. Locality: Near the Hidden Treasure Drift Mine, Forest Hill Divide, Placer County, California.
Donor: H. W. Soule, January, 1940.

20996 ALBITE Feldspar (Moonstone). Locality: Near Plush and northeast of Hart Mountain, Lake County, Oregon.
Donor: Gus Dunn. January, 1940.

LABORATORY

George L. Gary, Mineral Technologist

Since 1866 many lists have been published showing localities of California minerals. The last one "Minerals of California," by Adolf Pabst, was published in 1938 by the Division of Mines as Bulletin No. 113.

It is the intention of the Division of Mines to publish in the quarterly new localities for minerals that are received by the laboratory for determination. So that this information may be accurate, it is requested that all specimens submitted for classification be accompanied by a letter giving the exact location where the material was found.

Corrections will also be noted as well as additions when called to our attention.

CORRECTIONS AND ADDITIONS TO BULLETIN No. 113

54. **Wolframite,** forms a series of iron-manganese tungstates varying from **ferberite,** $FeWO_4$, to **hübnerite**, $MnWO_4$. It has been suggested that ferberite should include that portion of the series containing not over 20% $MnWO_4$; hübnerite the portion containing not over 20% $FeWO_4$; and wolframite the remainder. Hübnerite associated with triplite occurs at Camp Signal about nine miles north of Goffs, San Bernardino County, and, as noted in the July quarterly (page 343), at Colorado Hill, near Loope, Alpine County.

55. **Pectolite,** a calcium and sodium silicate in fibrous massive forms was found a few miles north of Vallejo, in Napa County.

56. Correction: Bulletin No. 113, page 126, Los Angeles County. This occurrence at Banning should have been listed under Riverside County.

57. **Vanadinite,** a lead chloro-vanadate, associated with sphalerite was found in straw-yellow incrustations on limestone, near Coleville, Mono County.

58. **Litharge** and **massicot,** monoxides of lead occurred as scaly masses on a specimen of quartz containing considerable galena, a sulphide of lead, from nine miles southeast of Bigpine, Inyo County.

59. **Halotrichite,** a hydrous iron aluminum sulphate, occurs in white silky fibrous forms in clay in Sec. 32, T. 3 S., R. 4 E., M. D. M., San Joaquin County.

60. **Collophane,** a hydrous calcium phosphate, occurs in limestone about nine miles southeast of Keeler, Inyo County.

61. **Iddingsite,** a hydrous magnesium and iron silicate occurs associated with olivine in Trinity County.

62. **Amblygonite,** a fluo-phosphate of aluminum and lithium, occurs in white massive forms on Turtle Mountain, San Bernardino County.

63. **Chromrutile,** a new mineral from California was reported by Samuel G. Gordon and Earl V. Shannon, Am. Mineralogist 13, 69 (Feb., 1928). The mineral occurs as small, brilliant black crystals, with kämmererite, on specimens of chromite from the Red Ledge mine, in the Washington district of Nevada Co., California. An analysis by Shannon gave: SiO_2 5.51, TiO_2 69.71, Al_2O_3 0.57; Fe_2O_3 0.80, Cr_2O_3 16.61, CaO 0.76, MgO 5.52, ignition 1.48, sum 100.96; hence the name chromrutile. The mineral is distinct from rutile, however, crystallographically, the crystals having the symmetry of the tetragonal bipyramidal class (Scheelite type).

64. **Kämmererite** occurs with chromrutile on specimens of chromite from the Red Ledge mine, in the Washington district of Nevada County.

65. **Clinoferrosilite,** an iron metasilicate, Fe Si O_3, a member of the pyroxene group was reported by N. L. Bowen in the Am. Jour. Sci., (5), vol. 30, pp. 481-494, 1935. It was found as minute needles in lithophysae in obsidian in the Coso Mountains, Inyo Co.

66. Correction: Bulletin No. 113, page 122. MINIUM-READ LEAD, should be MINIUM-RED LEAD.

67. The mineral **foshagite** found at Crestmore, Riverside Co., has been shown to be identical with **hillebrandite,** $Ca_2SiO_4.H_2O$. Orthorhombic; radiating fibrous. H.-5.5. G.-2.7. Fusible with difficulty. Color white. In Bulletin 113 this mineral should be referred to as **hillebrandite.**

68. **Spinel,** a magnesium aluminum oxide has been reported in massive and octahedral forms northwest of Anza and in the Thomas Mountain district, Riverside County.

69. **Alunogen,** a hydrous aluminum sulfate was found on mine timbers in the old Kilaga mine, 3 miles east of Lincoln, Placer County.

70. Correction: July quarterly (page 343) No. 34; Armagosa should be Amargosa.

71. **Vivianite,** a hydrous ferrous phosphate. Concretions in diatomite of late tertiary lake beds, occur near Burney, Shasta County.

72. **Ferrimolybdite,** a hydrous iron molydate occurs in sulfur-yellow fibrous crystals in Sec. 10-11-14-15, T. 30 S., R. 36 E., M. D. M., Kern County.

LIBRARY

John C. O'Brien, Librarian

In addition to the numerous standard works, authoritative information on many phases of the mining and mineral industry is constantly being issued in the form of reports and bulletins by various government agencies.

The library of the Division of Mines contains over six thousand selected volumes on mines, mining and allied subjects, and it is also a repository for reports and bulletins of the technical departments of federal and state governments and of educational institutions, both domestic and foreign.

It is not the dearth of the latter publications, but rather a lack of knowledge of just what has been published and where the reports may be consulted or obtained, that embarrasses the ordinary person seeking specific information.

To assist in making the public acquainted with this valuable source of current technical information, California Journal of Mines and Geology contains under this heading a list of all books and official reports and bulletins received which pertain particularly to mining in California.

Files of all the leading technical journals will be found in the library, and county and state maps, topographical sheets and geological folios. Current copies of local newspapers published in the mining centers of the state are available for reference.

The library and reading room are open to the public during the usual office hours, when the librarian may be freely called upon for all necessary assistance.

OFFICIAL PUBLICATIONS RECEIVED WHICH HAVE ESPECIAL INTEREST OR REFERENCE TO CALIFORNIA

Governmental, National:

U. S. Geological Survey:

Water Supply Papers:

845 Water Levels and Artesian Pressure in Observation Wells in the U. S. in 1938.

860 Surface Water Supply of the U. S., 1938, part 10, The Great Basin.

861 Surface Water Supply of the U. S., 1938, part 11, Pacific Slope Basins in California.

864 Surface Water Supply of the U. S., 1938, part 14, Pacific Coast Basins in Oregon and Lower Columbia River Basin.

U. S.

Bulletins

909 D Geophysical Abstracts 95—October-December, 1938.

Topographic Quadrangles:

Acton Quadrangle, Los Angeles County.

Bartle Quadrangle, Los Angeles County.

Boneyard Canyon Quadrangle, Los Angeles County.

Burney Quadrangle, Shasta County.
Glendora Quadrangle, Los Angeles County.
La Crescenta Quadrangle, Los Angeles County.
Mt. Wilson Quadrangle, Los Angeles County.
Yreka Quadrangle, Siskiyou County.

U. S. BUREAU OF MINES:

Information Circulars:

7092 Coal-Mine Explosions and Coal—and Metal Mine Fires in the U. S. during the Fiscal Year ended June 30, 1939.
7097 Strategic Minerals Investigation Procedure followed by the Bureau of Mines.

Report of Investigations:

3477 Progress Reports—Metallurgical Division 33, Manganese and its Alloys.
3479 Review of Cutler's Rule of Well Spacing.
3481 Bureau of Mines—A. P. I.—Pressure Core Barrel.
(Progress Report on it's design and development).

BOOKS

Annual Review—Petroleum World, 1939.
Annual Report of the Smithsonian Institute, 1938.
Decisions of the Department of the Interior, Vol. 56, June 30, 1936—Nov. 28, 1938.
Statistical Year Book, 1938, of the International Tin Research and Development Council.
The Examination of Fragmental Rocks by Frederick G. Tickell.

PUBLICATIONS RECEIVED CURRENTLY AND FORMER REPORTS AVAILABLE FOR REFERENCE

Governmental, State.

Alabama Geological Survey, University.
Arizona Bureau of Mines, Tucson.
Arkansas Geological Survey, Little Rock.
Colorado Bureau of Mines, Denver.
Connecticut Geological and Natural History Survey, Hartford.
Florida Department of Conservation, Tallahassee.
Georgia Division of Geology, Atlanta.
Idaho Bureau of Mines and Geology, Moscow.
Illinois Geological Survey, Urbana.
Iowa Geological Survey, Des Moines.
State Geological Survey of Kansas, Lawrence.
Kentucky Geological Survey, Frankfort.
Louisiana Department of Conservation, New Orleans.
Maine State Geologist, Augusta.
Maryland Geological Survey, Baltimore.
Michigan Geological Survey, Lansing.
Minnesota Geological Survey, Minneapolis.
Mississippi State Geological Survey, University.
Missouri Bureau of Geology & Mines, Rolla.
Montana Bureau of Mines and Geology, Butte.
Nebraska Geological Survey, Lincoln.
Nevada State Bureau of Mines, Reno.
New Jersey Department of Conservation and Development, Trenton.
New Mexico Bureau of Mines and Mineral Resources, Socorro.
North Carolina Geological & Economic Survey, Chapel Hill.
North Dakota Geological Survey, Grand Forks.
Ohio Geological Survey, Columbus.
Oklahoma Geological Survey, Norman.
Oregon State Department of Geology and Mineral Industries, Portland.
Pennsylvania Topographic and Geological Survey, Harrisburg.
South Dakota State Geological Survey, Vermillion.
Tennessee Division of Geology, Nashville.

Texas Bureau of Economic Geology, Austin.
Virginia Geological Survey, University.
Washington State Department of Conservation and Development, Pullman.
West Virginia Geological Survey, Morgantown.
Wisconsin Geological & Natural History Survey, Madison.
Wyoming Geological Survey, Cheyenne.

Governmental, Foreign.

Alberta Research Council, Edmonton.
Argentina Direccion General de Minas y Geologica, Buenos Aires.
British Columbia Minister of Mines, Victoria.
British Museum and Natural History, London.
Canada Department of Mines, Ottawa.
Cuerpo de Ingenieros de Minas y Aguas del Peru, Lima.
Geological Service of Minas Geraes, Bella Horizonte, Brazil.
Geological Survey of Scotland.
Instituto Historica e Geographico Rio de Janeiro.
Museo de Historia Natural de Montevideo, Uruguay.
New South Wales Department of Mines, Sydney, Australia.
New Zealand Geological Survey Branch, Wellington.
Nova Scotia Department of Public Works and Mines, Halifax.
Ontario Department of Mines, Toronto, Canada.
Quebec Bureau of Mines, Quebec.
Queensland Department of Mines, Brisbane, Australia.
South Australia Department of Mines, Adelaide.
Transvaal Chamber of Mines, Johannesburg, South Africa.
Western Australia, Geological Survey, Perth.

Societies and Educational Institutions.

Academia de Ciencias y Artes de Barcelona, Spain.
Academy of Natural Sciences, of Philadelphia.
American Association of Petroleum Geologists, Tulsa, Oklahoma.
American Geographical Society of New York.
American Institute of Mining and Metallurgical Engineers, New York.
American Journal of Science, New Haven, Conn.
American Philosophical Society, Philadelphia.
Australian Museum, Sydney.
California Academy of Sciences, San Francisco.
Carnegie Institution of Washington.
Cleveland Museum of Natural History, Cleveland, Ohio.
Colorado College Publications, Colorado Springs.
Colorado Scientific Society, Denver.
Commonwealth Club, San Francisco.
Economic Geology, Lancaster, Pa.
Field Museum of Natural History, Chicago.
Franklin Institute of the State of Pennsylvania, Lancaster, Pa.
Geological Society of America, Columbia University, New York.
Geographical Society of London.
Institution of Mining and Metallurgy, London.
Instituto Geologico de Mexico, Mexico, D. F.
Journal of Geology, Chicago.
Mineralogical Society of America, Menasha, Wisconsin.
Michigan College of Mining and Technology, Houghton.
Mining and Metallurgical Society of America, New York.
Museu Nacional, Rio de Janeiro.
National Research Council, Washington, D. C.
New York Academy of Sciences, New York.
New York State Museum, Albany.
Pennsylvania State College, State College.
Philippine Journal of Science, Manila.
Royal Society of South Australia, Adelaide.
Seismological Society of America, Stanford University.
Sierra Club, San Francisco.
Society of Economical Paleontologists and Mineralogists, Fort Worth, Texas.

Southern California Acadamy of Sciences, Los Angeles.
University of California Publications in Engineering, Berkeley.
University of California Publications in Geography, Berkeley.
University of California Publications in Geology, Berkeley.
University of Harvard, Department of Mineralogy and Petrography, Cambridge, Mass.

Current Magazines on File.

For the convenience of persons wishing to consult the technical magazines in the reading room, a list of those on file is appended:

Asbestos, Philadelphia, Pennsylvania.
Brick and Clay Record, Chicago.
California Journal of Development, San Francisco.
California Mining Journal, Auburn.
California Oil World, Los Angeles.
California Safety News, San Francisco.
Canadian Mining Journal, Gardenvale, Quebec.
Chemical and Metallurgical Engineering, New York City.
Chemical Engineering and Mining Review, Melbourne, Australia.
Civil Engineering, New York City.
Colorado School of Mines, Golden, Colorado.
Conservationist, Sacramento, California.
Engineering and Mining Journal, New York City.
Fuel Oil, Chicago, Illinois.
Fusion Facts, Whittier, California.
Gemmologist, London.
Gold, Toronto, Canada.
Grizzly Bear, Los Angeles.
Hercules Mixer, Wilmington, Delaware.
Independent Monthly, Tulsa, Oklahoma.
Lubrication, The Texas Co., New York City.
Metals and Alloys, Pittsburgh, Pennsylvania.
Mine and Mill World Digest, San Francisco.
Mining and Contracting Review, Salt Lake City.
Mineralogist, Portland, Oregon.
Mining Congress Journal, Washington, D. C.
Mining and Industrial News, San Francisco.
Mining and Geological Journal, Melbourne, Victoria, Australia.
Mining Journal, London.
Mining Journal, Phoenix, Arizona.
Mining and Metallurgy, New York City.
Mining Review, Salt Lake City.
Nevada Mining Bulletin, Las Vegas, Nevada.
Nickel Steel Topics, New York City.
Northwest Mining, Spokane, Washington.
Northwest Science, Cheney, Washington.
Oil and Gas Journal, Tulsa, Oklahoma.
Oil, Paint and Drug Reporter, New York City.
Oil Weekly, Houston, Texas.
Pacific Purchaser, San Francisco.
Pacific Chemical and Metallurgical Industries, San Francisco.
Petroleum World, Los Angeles.
Queensland Government Mining Journal, Brisbane, Australia.
Rock Products, Chicago.
Rocks and Minerals, Peekskill, New York.
Sands, Clays and Minerals, Chatteris, England.
Scientific American, New York City.
Southwest Builder and Contractor, Los Angeles.
Stabilizer, Los Angeles.
Standard Oil Bulletin, San Francisco.
Stone, New York City.
Western Mining News, San Francisco.

Newspapers.

The following papers are received and kept on file in the library:

Alaska Weekly, Seattle, Washington.
Amador Dispatch, Jackson, California.
Banner, Sonora, California.
Barstow Printer, Barstow, California.
Bridgeport Chronicle-Union, Bridgeport, California.
Calaveras Californian, Angels Camp, California.
Calaveras Prospect, San Andreas, California.
Colusa Sun-Herald, Colusa, California.
Daily Commercial News, San Francisco, California.
Daily Midway Driller, Taft, California.
Del Norte Triplicate, Crescent City, California.
Denver Mining Record, Denver, Colorado.
Georgetown Gazette, Georgetown, California.
Inyo Independent, Independence, California.
Inyo Register, Bishop, California.
Las Vegas Age, Las Vegas, Nevada.
Livermore Herald, Livermore, California.
Los Angeles Times, Los Angeles, California.
Mariposa Gazette, Mariposa, California.
Mercury Register, Oroville, California.
Mohave Miner, Kingman, Arizona.
Mojave-Randsburg Record, Mojave, California.
Morning Union, Grass Valley, California.
Mountain Messenger, Downieville, California.
Needles Nugget, Needles, California.
Nevada City Nugget, Nevada City, California.
Nevada Mining Bulletin, Las Vegas, Nevada.
Oil Marketer, Bayonne, New Jersey.
Placer Herald, Auburn, California.
Plumas Independent, Quincy, California.
San Diego News, San Diego, California.
Shasta Courier, Redding, California.
Siskiyou News, Yreka, California.
Tehachapi News, Tehachapi, California.
Terra Bella News, Terra Bella, California.
Tuolumne Independent, Sonora, California.
Tuolumne Prospector, Tuolumne, California.
Union Democrat, Sonora, California.
Ventura County News, Ventura, California.
Waterford News, Waterford, California.
Weekly Trinity Journal, Weaverville, California.
Western Mineral Survey, Salt Lake City, Utah.
Western Sentinel, Etna Mills, California.

EMPLOYMENT SERVICE

Following the establishment of the Mining Division branch offices in 1919, a free technical employment service was offered as a mutual aid to mine operators and technical men for the general benefit of the mineral industry.

Briefly summarized, men desiring positions are registered, the cards containing an outline of the applicant's qualifications, position wanted, salary desired, etc., and as notices of 'positions open' are received, the names and addresses of all applicants deemed qualified are sent to the prospective employer for direct negotiations.

Telephone and telegraphic communications are also given immediate attention.

Technical men, or those qualified for supervisory positions, and vacancies of like nature only, are registered, as no attempt will be made to supply common mine and mill labor.

Registration cards for the use of both prospective employers and employees may be obtained upon request, and a cordial invitation is extended to the industry to make free use of the facilities afforded. Parties interested should communicate direct with our San Francisco office.

PRODUCERS AND CONSUMERS

The producer and consumer of mineral products are mutually dependent upon each other for their prosperity, and one of the most direct aids rendered by this Division to the mining industry in the past has been that of bringing producers and consumers into direct touch with each other.

This work has been carried on largely by correspondence, supplemented by personal consultation. Lists of buyers of all the commercial minerals produced in California have been made available to producers upon request, and likewise the owners of undeveloped deposits of various minerals, and producers of them, have been made known to those looking for raw mineral products.

When the publication of *Mining in California* was on a monthly basis, current inquiries from buyers and sellers were summarized and lists of mineral products or deposits 'wanted' or 'for sale' included in each issue.

It is important that inquiries of this nature reach the mining public as soon as possible and in order to avoid the delay incident to the present quarterly publication of CALIFORNIA JOURNAL OF MINES AND GEOLOGY, these lists are now issued monthly in the form of a mimeographed sheet under the title of 'Commercial Mineral Notes,' and sent to those on the mailing list of CALIFORNIA JOURNAL OF MINES AND GEOLOGY.

PUBLICATIONS OF THE DIVISION OF MINES

During the past fifty-six years, in carrying out the provisions of the organic act creating the former California State Mining Bureau, there have been published many reports, bulletins and maps which go to make up a library of detailed information on the mineral industry of the State, a large part of which could not be duplicated from any other source.

One feature that has added to the popularity of the publications is that many of them have been distributed without cost to the public, and even the more elaborate ones have been sold at a price which barely covers the cost of printing.

Owing to the fact that funds for the advancing of the work of this department have usually been limited, the reports and bulletins mentioned are printed in limited editions many of which are now entirely exhausted.

Copies of such publications are available for reference, however, in the offices of the Division of Mines, in the Ferry Building, San Francisco; State Building, Los Angeles; State Office Building, Sacramento; Redding; and Division of Oil and Gas at Santa Barbara, Santa Paula, Taft, Bakersfield, Coalinga. They may also be found in many public, private and technical libraries in California and other states and foreign countries.

A catalog of all publications from 1880 to 1917, giving a synopsis of their contents, is issued as Bulletin No. 77.

Publications in stock may be obtained postpaid by addressing the San Francisco, Los Angeles or Sacramento offices and enclosing the requisite amount.

Remittances of stamps in an amount not to exceed 26 cents, currency or coin will be accepted at sender's risk. Payment is preferred in the form of money orders.

Money orders should be made payable to the Division of Mines.

NOTE.—The Division of Mines frequently receives requests for some of the early Reports and Bulletins now out of print, and it will be appreciated if parties having such publications and wishing to dispose of them will advise this office.

Write for latest revised price list.

REPORTS

Asterisks (**) indicate the publication is out of print.

	Price (including postage and sales tax)
**First Annual Report of the State Mineralogist, 1880, 43 pp. Henry G. Hanks	----
**Second Annual Report of the State Mineralogist, 1882, 514 pp., 4 illustrations, 1 map. Henry G. Hanks	----
**Third Annual Report of the State Mineralogist, 1883, 111 pp., 21 illustrations. Henry G. Hanks	----
**Fourth Annual Report of the State Mineralogist, 1884, 410 pp., 7 illustrations. Henry G. Hanks	----
**Fifth Annual Report of the State Mineralogist, 1885, 234 pp., 15 illustrations, 1 geological map. Henry G. Hanks	----
Sixth Annual Report of the State Mineralogist, Part I, 1886, 145 pp., 3 illustrations, 1 map. Henry G. Hanks. Price $0.75, sales tax $0.02	$0.77
Part II, 1887, 222 pp., 36 illustrations. William Irelan, Jr. Price $0.75, sales tax $0.02	.77
**Seventh Annual Report of the State Mineralogist, 1887, 315 pp. William Irelan, Jr.	----
**Eighth Annual Report of the State Mineralogist, 1888, 948 pp., 122 illustrations. William Irelan, Jr.	----
**Ninth Annual Report of the State Mineralogist, 1889, 352 pp., 57 illustrations, 2 maps. William Irelan, Jr.	----
**Tenth Annual Report of the State Mineralogist, 1890, 983 pp., 179 illustrations, 10 maps. William Irelan, Jr.	----
Eleventh Report (First Biennial) of the State Mineralogist, for the two years ending September 15, 1892, 612 pp., 73 illustrations, 4 maps. William Irelan, Jr. Price $1.50, sales tax $0.05	1.55
**Twelfth Report (Second Biennial) of the State Mineralogist, for the two years ending September 15, 1894, 541 pp., 101 illustrations, 5 maps. J. J. Crawford	----
**Thirteenth Report (Third Biennial) of the State Mineralogist, for the two years ending September 15, 1896, 726 pp., 93 illustrations, 1 map. J. J. Crawford	----
Chapters of the State Mineralogist's Report, XIV Biennial Period, 1913-1914, Fletcher Hamilton:	
**Mines and Mineral Resources, Amador, Calaveras and Tuolumne Counties, 172 pp., paper	----
Mines and Mineral Resources, Colusa, Glenn, Lake, Marin, Napa, Solano, Sonoma and Yolo Counties, 208 pp., paper. Price $0.75, sales tax $0.02	.77
**Mines and Mineral Resources, Del Norte, Humboldt and Mendocino Counties, 59 pp., paper	----
**Mines and Mineral Resources, Fresno, Kern, Kings, Madera, Mariposa, Merced, San Joaquin and Stanislaus Counties, 220 pp., paper	----
**Mines and Mineral Resources of Imperial and San Diego Counties, 113 pp., paper	----
**Mines and Mineral Resources, Shasta, Siskiyou and Trinity Counties, 180 pp., paper	----
**Fourteenth Report of the State Mineralogist, for the Biennial Period 1913-1914, Fletcher Hamilton, 1915: A General Report on the Mines and Mineral Resources of Amador, Calaveras, Tuolumne, Colusa, Glenn, Lake, Marin, Napa, Solano, Sonoma, Yolo, Del Norte, Humboldt, Mendocino, Fresno, Kern, Kings, Madera, Mariposa, Merced, San Joaquin, Stanislaus, San Diego, Imperial, Shasta, Siskiyou and Trinity Counties, 974 pp., 275 illustrations, cloth	----
Chapters of the State Mineralogist's Report, XV Biennial Period, 1915-1916, Fletcher Hamilton:	
**Mines and Mineral Resources, Alpine, Inyo and Mono Counties, 176 pp., paper	----
Mines and Mineral Resources, Butte, Lassen, Modoc, Sutter and Tehama Counties, 91 pp., paper. Price $0.75, sales tax $0.02	.77

REPORTS—Continued

Asterisks (**) indicate the publication is out of print. Price (including postage and sales tax)

Mines and Mineral Resources, El Dorado, Placer, Sacramento and Yuba Counties, 198 pp., paper ---- Price $0.75, sales tax $0.02 $0.77

Mines and Mineral Resources, Monterey, San Benito, San Luis Obispo, Santa Barbara and Ventura Counties, 183 pp., paper ---- Price $0.75, sales tax $0.02 .77

**Mines and Mineral Resources, Los Angeles, Orange and Riverside Counties, 136 pp., paper ---- ----

**Mines and Mineral Resources, San Bernardino and Tulare Counties, 186 pp., paper ---- ----

**Fifteenth Report of the State Mineralogist, for the Biennial Period 1915-1916, Fletcher Hamilton, 1917:

A General Report on the Mines and Mineral Resources of Alpine, Inyo, Mono, Butte, Lassen, Modoc, Sutter, Tehama, Placer, Sacramento, Yuba, Los Angeles, Orange, Riverside, San Benito, San Luis Obispo, Santa Barbara, Ventura, San Bernardino and Tulare Counties, 990 pp., 413 illustrations, cloth ---- ----

Chapters of the State Mineralogist's Report XVI, Biennial Period, 1917-1918, Fletcher Hamilton:

Mines and Mineral Resources of Nevada County, 270 pp., paper ---- Price $1.00, sales tax $0.03 1.03

Mines and Mineral Resources of Plumas County, 188 pp., paper ---- Price $0.75, sales tax $0.02 .77

Mines and Mineral Resources of Sierra County, 144 pp., paper ---- Price $0.75, sales tax $0.02 .77

Seventeenth Report of the State Mineralogist, 1920, 'Mining in California during 1920,' Fletcher Hamilton; 562 pp., 71 illustrations, cloth ---- Price $2.50, sales tax $0.08 2.58

Eighteenth Report of the State Mineralogist, 1922, 'Mining in California,' Fletcher Hamilton. Chapters published monthly beginning with January, 1922:

**January, **February, March, April, **May, June, July, August, September, October, **November, December, 1922 ---- ------

Chapters of Nineteenth Report of the State Mineralogist, 'Mining in California,' Fletcher Hamilton and Lloyd L. Root. January, February, March, September, 1923 ---- Price $0.40, sales tax $0.01 .41

Chapters of Twentieth Report of the State Mineralogist, 'Mining in California,' Lloyd L. Root. Published quarterly. January, April, July, October, 1924, per copy ---- Price $0.40, sales tax $0.01 .41

Chapters of Twenty-first Report of the State Mineralogist, 'Mining in California,' Lloyd L. Root. Published quarterly:

January, 1925, Mines and Mineral Resources of Sacramento, Monterey and Orange Counties ---- Price $0.40, sales tax $0.01 .41

April, 1925, Mines and Mineral Resources of Calaveras, Merced, San Joaquin, Stanislaus and Ventura Counties ---- Price $0.40, sales tax $0.01 .41

July, 1925, Mines and Mineral Resources of Del Norte, Humboldt and San Diego Counties ---- Price $0.40, sales tax $0.01 .41

**October, 1925, Mines and Mineral Resources of Siskiyou, San Luis Obispo and Santa Barbara Counties ---- ----

Chapters of Twenty-second Report of the State Mineralogist, 'Mining in California,' Lloyd L. Root. Published quarterly:

**January, 1926, Mines and Mineral Resources of Trinity and Santa Cruz Counties ---- ----

April, 1926, Mines and Mineral Resources of Shasta, San Benito and Imperial Counties ---- Price $0.40, sales tax $0.01 .41

July, 1926, Mines and Mineral Resources of Marin and Sonoma Counties Price $0.40, sales tax $0.01 .41

**October, 1926, Mines and Mineral Resources of El Dorado and Inyo Counties, also report on Minaret District, Madera County ---- ----

Chapters of Twenty-third Report of the State Mineralogist, 'Mining in California,' Lloyd L. Root. Published quarterly:

REPORTS—Continued

Asterisks (**) indicate the publication is out of print.	Price (including postage and sales tax)
January, 1927, Mines and Mineral Resources of Contra Costa County; Santa Catalina Island — Price $0.40, sales tax $0.01	$0.41
April, 1927, Mines and Mineral Resources of Amador and Solano Counties — Price $0.40, sales tax $0.01	.41
**July, 1927, Mines and Mineral Resources of Placer and Los Angeles Counties	--
October, 1927, Mines and Mineral Resources of Mono County — Price $0.40, sales tax $0.01	.41
Chapters of Twenty-fourth Report of the State Mineralogist, 'Mining in California,' Lloyd L. Root. Published quarterly:	
January, 1928, Mines and Mineral Resources of Tuolumne County — Price $0.40, sales tax $0.01	.41
April, 1928, Mines and Mineral Resources of Mariposa County — Price $0.40, sales tax $0.01	.41
**July, 1928, Mines and Mineral Resources of Butte and Tehama Counties	----
October, 1928, Mines and Mineral Resources of Plumas and Madera Counties — Price $0.40, sales tax $0.01	.41
Chapters of Twenty-fifth Report of the State Mineralogist, 'Mining in California,' Walter W. Bradley. Published quarterly:	
January, 1929, Mines and Mineral Resources of Lassen, Modoc and Kern Counties; also on Special Placer Machines — Price $0.40, sales tax $0.01	.41
**April, 1929, Mines and Mineral Resources of Sierra, Napa, San Francisco and San Mateo Counties	----
July, 1929, Mines and Mineral Resources of Colusa, Fresno and Lake Counties — Price $0.40, sales tax $0.01	.41
October, 1929, Mines and Mineral Resources of Glenn, Alameda, Mendocino and Riverside Counties — Price $0.40, sales tax $0.01	.41
Chapters of Twenty-sixth Report of the State Mineralogist, 'Mining in California,' Walter W. Bradley. Published quarterly:	
January, 1930, Mines and Mineral Resources of Santa Clara County; also Barite in California — Price $0.40, sales tax $0.01	.41
**April, 1930, Mines and Mineral Resources of Nevada County; also Mineral Paint Materials in California	----
**July, 1930, Mines and Mineral Resources of Yuba and San Bernardino Counties; also Commercial Grinding Plants in California	----
October, 1930, Mines and Mineral Resources of Butte, Kings and Tulare Counties; also Geology of Southwestern Mono County (Preliminary) — Price $0.40, sales tax $0.01	.41
Chapters of Twenty-seventh Report of the State Mineralogist, 'Mining in California,' Walter W. Bradley. Published quarterly:	
January, 1931. Preliminary Report of Economic Geology of the Shasta Quadrangle. Beryllium and Beryl. The New Tariff and Nonmetallic Products. Crystalline Talc. Decorative Effects in Concrete — Price $0.40, sales tax $0.01	.41
April, 1931, Stratigraphy of the Kreyenhagen Shale. Diatoms and Silicoflagellates of the Kreyenhagen Shale. Foraminifera of the Kreyenhagen Shale. Geology of Santa Cruz Island — Price $0.40, sales tax $0.01	.41
**July, 1931. (Yuba, San Bernardino.) Feldspar, Silica, Andalusite and Cyanite Deposits of California. Note on a Deposit of Andalusite in Mono County; its occurrence and chemical importance. Bill creating Trinity and Klamath River Fish and Game District and its effect upon mining	----
October, 1931. (Alpine.) Geology of the San Jacinto Quadrangle south of San Gorgonio Pass, California. Notes on Mining Activities in Inyo and Mono Counties in July, 1931 — Price $0.40, sales tax $0.01	.41
Chapters of Twenty-eighth Report of the State Mineralogist, 'Mining in California,' Walter W. Bradley. Published quarterly:	
January, 1932, Economic Mineral Deposits of the San Jacinto Quadrangle. Geology and Physical Properties of Building Stone from Car-	

REPORTS—Continued

Asterisks (**) indicate the publication is out of print. Price (including postage and sales tax)

mel Valley. Contributions to the Study of Sediments. Sediments of Monterey Bay. Sanbornite____________Price $0.40, sales tax $0.01 $0.41

**April, 1932. Elementary Placer Mining Methods and Gold Saving Devices. The Pan, Rocker and Sluice Box. Prospecting for Vein Deposits. Bibliography of Placer Mining__________________________ ----

Abstract from April quarterly: Elementary Placer Mining Methods and Gold Saving Devices. Types of Deposits, Simple Equipment. Special Machines. Dry Washing. Black Sand Treatment. Marketing of Products. Placer Mining Areas. Laws. Prospecting for Quartz Veins. Bibliography (mimeographed)__Price $0.25, sales tax $0.01 .26

July-October. (Ventura.) Report accompanying Geologic Map of Northern Sierra Nevada. Fossil Plants in Auriferous Gravels of the Sierra Nevada. Glacial and Associated Stream Deposits of the Sierra Nevada. Jurassic and Cretaceous Divisions in the Knoxville-Shasta Succession of California. Geology of a part of the Panamint Range. Economic Report of a Part of the Panamint Range. Acquiring Mining Claims Through Tax Title. The Biennial Report of State Mineralogist ______________________________Price $0.75, sales tax $0.02 .77

Chapters of Report XXIX, 1933 (quarterly): titled 'California Journal of Mines and Geology,' containing the following:

January-April. Gold Deposits of the Redding and Weaverville Quadrangles. Geologic Formations of the Redding-Weaverville District, Northern California. Geology of Portions of Del Norte and Siskiyou Counties. Applications of Geology to Civil Engineering. The Lakes of California. Discovery of Piedmontite in the Sierra Nevada. Tracing 'Buried River' Channel Deposits by Geomagnetic Methods. Geologic Map of Redding-Weaverville District, showing gold mines and prospects. Geologic map showing various mines and prospects of part of Del Norte and Siskiyou Counties__________________________ Price $1.00, sales tax $0.03 1.03

July-October. Gold Resources of Kern County. Limestone Deposits of the San Francisco Region. Limestone Weathering and Plant Associations of the San Francisco Region. Booming, Death Valley National Monument, California. Placer Mining Districts, Senate Bill 480. Navigable Waters, Assembly Bill 1543_________________ Price $1.00, sales tax $0.03 1.03

Chapters of Report XXX, 1934 (quarterly): titled 'California Journal of Mines and Geology,' containing the following:

January. Resurrection of Early Surfaces in the Sierra Nevada. Geology and Mineral Resources of Northeastern Madera County. Geology and Mineral Deposits of Laurel and Convict Basins, Southwestern Mono County. Notes on Sampling as Applied to Gold Quartz Deposits___ Price $0.60, sales tax $0.02 .62

April-July. Elementary Placer Mining in California and Notes on the Milling of Gold Ores__________________Price $1.00, sales tax $0.03 1.03

October. Current Mining Developments in Northern California. Current Mining Activity in Southern California. Geology and Mineral Resources of the Julian District, San Diego County. Geology and Mineral Resources of Elizabeth Lake Quadrangle. Dry Placers of Northern Mojave Desert. Biennial Report of State Mineralogist. Assessment Work Within Withdrawn Areas______________________ Price $0.60, sales tax $0.02 .62

Chapters of Report XXI, 1935 (quarterly): titled 'California Journal of Mines and Geology,' containing the following:

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**Register of Oil Wells, with Map, Los Angeles City (1906)	----

OTHER MAPS

**Map of California, Showing Mineral Deposits (50x60 in.)	----
**Map of Forest Reserves in California	----
**Mineral and Relief Map of California	----
**Map of El Dorado County, Showing Boundaries, National Forests	----
**Map of Madera County, Showing Boundaries, National Forests	----
**Map of Placer County, Showing Boundaries, National Forests	----
**Map of Shasta County, Showing Boundaries, National Forests	----
**Map of Sierra County, Showing Boundaries, National Forests	----
**Map of Siskiyou County, Showing Boundaries, National Forests	----
**Map of Tuolumne County, Showing Boundaries, National Forests	----

OTHER MAPS—Continued

Asterisks (**) indicate the publication is out of print.

	Price (including postage and sales tax)
**Map of Mother Lode Region	----
**Map of Desert Region of Southern California	----
Map of Minaret District, Madera County—Price $0.25, sales tax $0.01	$0.26
**Map of Copper Deposits in California	----
**Map of Calaveras County	----
**Map of Plumas County	----
**Map of Trinity County	----
**Map of Tuolumne County	----
**Geographical Map of Inyo County. Scale 1 inch equals 4 miles	----
**Map of California accompanying Bulletin No. 89, showing generalized classification of land with regard to oil possibilities. Map only, without Bulletin	------
Geologic Map of California, 1916. Scale 1 inch equals 12 miles. Shows railroads, highways, post offices and other towns. Geological details lithographed in 23 colors. Mounted—Price $2.75, sales tax $0.08	2.83
**Unmounted	----
Geologic Map of California, 1938. Scale 8 miles per inch. Lithographed in 80 distinguishing colors and patterns showing geologic units. In 6 sections, each 32 in. x 42 in. Set of 6 sheets, unmounted. Sheets not sold separately—Price $4.00, sales tax $0.12	4.12
**Topographic Map of Sierra Nevada Gold Belt, showing distribution of auriferous gravels, accompanying Bulletin No. 92. In 4 colors (also sold singly)	----
Geologic Map of Northern Sierra Nevada, showing Tertiary River Channels and Mother Lode Belt accompanying July-October Chapter of Report XXVIII of the State Mineralogist. (Sold singly)—Price $0.40, sales tax $0.01	.41
Map of Northern California, showing rivers and creeks which produced placer gold in 1932—Price $0.25, sales tax $0.01	.26
Mother Lode Geologic and claim maps in 5 county sections: El Dorado, Amador, Calaveras, Tuolumne and Mariposa. Single sections .25c. Set of 5—Price $1.00, sales tax $0.03	1.03
Map of Mariposa County, showing principal gold mines—Price $0.25, sales tax $0.01	.26
Geologic Map of Elizabeth Lake Quadrangle, Los Angeles and Kern Counties (accompanying October Chapter of Report XXX), sold separately—Price $0.25, sales tax $0.01	.26
Map of Western Portion of Siskiyou County Showing Location of Principal Gold Mines (accompanying July Chapter of Report XXXI), sold separately—Price $0.25, sales tax $0.01	.26
Geologic Map of Redding and Weaverville Quadrangles Showing Location of Gold Mines—Price $0.25, sales tax $0.01	.26
Map of Ancient Channel System, Calaveras County—Price $0.25, sales tax $0.01	.26
Map of Ancient Channels Between San Andreas and Mokelumne Hill—Price $0.25, sales tax $0.01	.26
Elizabeth Lake Quadrangle—Price $0.25, sales tax $0.01	.26
Minaret—Price $0.25, sales tax $0.01	.26
Perris Block Geologic—Price $0.25, sales tax $0.01	.26
Plumas County Geologic—Price $0.25, sales tax $0.01	.26
Shasta County Geologic—Price $0.25, sales tax $0.01	.26
El Dorado County—Price $0.25, sales tax $0.01	.26

OIL FIELD MAPS

The maps are revised from time to time as development work advances and ownerships change.

Map No. 1—Sargent, Santa Clara County—Price $0.75, sales tax $0.02	$0.77
Map No. 2—Santa Maria, including Cat Canyon and Los Alamos—Price $1.25, sales tax $0.04	1.29

OIL FIELD MAPS—Continued

The maps are revised from time to time as development work advances and ownerships change.

Map	Price	Sales tax	Price (including postage and sales tax)
Map No. 3—Santa Maria, including Casmalia and Lompoc	$1.25	$0.04	$1.29
Map No. 4—Brea Olinda and (East Portion) Coyote Hills, Los Angeles and Orange Counties	$1.25	$0.04	1.29
Map No. 6—Salt Lake-Beverly Hills, Los Angeles County	$1.25	$0.04	1.29
Map No. 7—Sunset and San Emidio, Kern County	$1.25	$0.04	1.29
Map No. 8—South Midway and Buena Vista Hills, Kern County	$1.25	$0.04	1.29
Map No. 9—North Midway and McKittrick, Kern County	$1.25	$0.04	1.29
Map No. 10—Belridge and McKittrick Front, Kern County	$1.25	$0.04	1.29
Map No. 11—Lost Hills and North Belridge, Kern County	$1.25	$0.04	1.29
Map No. 12—Devils Den, Kern County	$1.00	$0.03	1.03
Map No. 13—Kern River, Kern County	$1.00	$0.03	1.03
Map No. 14—Coalinga and E. Coalinga Extension, Fresno County	$1.50	$0.05	1.55
Map No. 15—Elk Hills, Kern County	$1.25	$0.04	1.29
Map No. 16—Ventura-Ojai, Ventura County	$1.25	$0.04	1.29
Map No. 17—Santa Paula-Sespe, including Bardsdale, South Mountain and Camarillo, Ventura County	$1.25	$0.04	1.29
Map No. 18—Piru-Simi-Newhall, Ventura County	$1.25	$0.04	1.29
Map No. 19—Arroyo Grande, San Luis Obispo County	$1.00	$0.03	1.03
Map No. 20—Long Beach, Los Angeles County	$1.75	$0.05	1.80
Map No. 21-B—Portion of District No. 5, showing boundaries of oil fields—Fresno, Kings and Kern Counties	$1.00	$0.03	1.03
Map No. 21-C—Portion of District No. 4, showing boundaries of oil fields—Kern, Kings and Tulare Counties	$1.25	$0.04	1.29
Map No. 22—Portion of District No. 3, showing boundaries of oil fields—Santa Barbara County	$0.75	$0.02	.77
Map No. 23—Portion of District No. 2, showing boundaries of oil fields—Ventura County	$1.00	$0.03	1.03
Map No. 24—Portion of District No. 1, showing boundaries of oil fields—Los Angeles and Orange Counties	$1.00	$0.03	1.03
Map No. 26—Huntington Beach, Orange County	$1.50	$0.05	1.55
Map No. 27—Santa Fe Springs, Los Angeles County	$1.25	$0.04	1.29
Map No. 28—Torrance, Los Angeles County	$1.25	$0.04	1.29
Map No. 29—Dominguez, Los Angeles County	$1.00	$0.03	1.03
Map No. 30—Rosecrans, Los Angeles County	$1.25	$0.04	1.29
Map No. 31—Inglewood, Los Angeles County	$1.25	$0.04	1.29
Map No. 32—Seal Beach, Los Angeles and Orange Counties	$1.25	$0.04	1.29
Map No. 33—Rincon, Ventura County	$1.50	$0.05	1.55
Map No. 34—Mt. Poso and Poso Creek, Kern County	$1.00	$0.03	1.03
Map No. 35—Round Mountain, Kern County	$1.00	$0.03	1.03

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OIL FIELD MAPS—Continued

The maps are revised from time to time as development work advances and ownerships change.

Map	Price	Price (including postage and sales tax)
Map No. 36—Kettleman Hills, Fresno, Kings and Kern Counties	Price $1.50, sales tax $0.05	$1.55
Map No. 37—Montebello, Los Angeles County	Price $1.00, sales tax $0.03	1.03
Map No. 38—Whittier, Los Angeles County	Price $1.25, sales tax $0.04	1.29
Map No. 39—West Coyote, Los Angeles and Orange Counties	Price $1.25, sales tax $0.04	1.29
Map No. 40—Elwood, Santa Barbara County, and La Goleta, Santa Barbara County	Price $1.25, sales tax $0.04	1.29
Map No. 41—Potrero, Los Angeles County	Price $1.00, sales tax $0.03	1.03
Map No. 42—Playa del Rey, Los Angeles County	Price $1.50, sales tax $0.05	1.55
Map No. 43—Capitan, Santa Barbara County	Price $1.00, sales tax $0.03	1.03
Map No. 44—Mesa, Santa Barbara County	Price $1.50, sales tax $0.05	1.55
Map No. 46—Richfield, Orange County	Price $1.25, sales tax $0.04	1.29
Map No. 48—Mountain View and Edison, Kern County	Price $1.25, sales tax $0.04	1.29
Map No. 49—Fruitvale, Kern County	Price $1.00, sales tax $0.03	1.03
Map No. 50—Wilmington, Los Angeles County	Price $1.25, sales tax $0.04	1.29
Map No. 51—Santa Maria Valley, Santa Barbara County	Price $1.00, sales tax $0.03	1.03
Map No. 52—El Segundo and Lawndale, Los Angeles County	Price $1.50, sales tax $0.05	1.55
Map No. 53—Rio Bravo, Greeley, Kern County	Price $1.25, sales tax $0.04	1.29
Map No. 54—Wasco Oil Field, Buttonwillow and Semitropic Gas Fields, Kern County	Price $1.25, sales tax $0.04	1.29
Map No. 55—Canal, Canfield Ranch, Coles Levee, Strand, and Ten Section, Kern County	Price $1.25, sales tax $0.04	1.29
Map No. 56—Paloma, Kern County	Price $1.25, sales tax $0.04	1.29

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STATE OF CALIFORNIA
DEPARTMENT OF NATURAL RESOURCES
RICHARD SACHSE, Director

DIVISION OF MINES
FERRY BUILDING, SAN FRANCISCO

WALTER W. BRADLEY State Mineralogist

Vol. 36 April, 1940 No. 2

CALIFORNIA JOURNAL

OF

MINES AND GEOLOGY

QUARTERLY CHAPTER
OF
STATE MINERALOGIST'S REPORT XXXVI

STATE DIVISION OF MINES
FERRY BUILDING, SAN FRANCISCO
CALIFORNIA

88203

DIVISION OF MINES

EXECUTIVE AND TECHNICAL STAFF

WALTER W. BRADLEY
State Mineralogist

OLAF P. JENKINS, Chief Geologist ---------- San Francisco
C. A. LOGAN, District Mining Engineer ---------- Sacramento
C. McK. LAIZURE, District Mining Engineer ---------- San Francisco
W. BURLING TUCKER, District Mining Engineer ---------- Los Angeles
REID J. SAMPSON, Assistant District Engineer ---------- Los Angeles
CHAS. V. AVERILL, District Mining Engineer ---------- Redding
GEORGE L. GARY, Mineral Technologist ---------- San Francisco
JOHN F. BONGARD, Ore-Buyers' Inspector ---------- San Francisco
HENRY H. SYMONS, Statistician and Curator ---------- San Francisco
J. C. O'BRIEN, Junior Mining Engineer (Librarian) ---------- San Francisco

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·DIVISION·OF·MINES·
·WALTER W. BRADLEY·
·STATE MINERALOGIST·
OUTLINE MAP
OF
CALIFORNIA
SCALE
O R E G O N
N E V A D A
P A C I F I C
O C E A N
M E X I C O
DEL NORTE
SISKIYOU
MODOC
HUMBOLDT
TRINITY
SHASTA
LASSEN
TEHAMA
PLUMAS
GLENN
BUTTE
SIERRA
MENDOCINO
NEVADA
LAKE
COLUSA
YUBA
SUTTER
PLACER
YOLO
EL DORADO
SONOMA
NAPA
AMADOR
ALPINE
SOLANO
CALAVERAS
MARIN
CONTRA COSTA
SAN JOAQUIN
TUOLUMNE
MONO
SAN FRANCISCO
ALAMEDA
STANISLAUS
MARIPOSA
SAN MATEO
SANTA CLARA
MERCED
MADERA
SANTA CRUZ
SAN BENITO
FRESNO
INYO
MONTEREY
KINGS
TULARE
SAN LUIS OBISPO
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NEVADA CY
UKIAH
COLUSA
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MARYSVILLE
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VENTURA
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SAN DIEGO
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Mining Division Boundaries.
Mining Division Offices.

PREFACE

The Division of Mines (formerly State Mining Bureau) is maintained for the purpose of assisting in all possible ways in the development of California's mineral resources.

As one means of offering tangible service to the mining public, the State Mineralogist for many years has issued an annual or a biennial report reviewing in detail the mines and mineral deposits of the various counties.

As a progressive step in advancing the interests of the mineral industry, and as permitting earlier distribution to the public, publication of the Annual Report of the State Mineralogist in the form of monthly chapters was begun in January, 1922, and continued until March, 1923. Owing to a lack of funds for printing this was changed to a quarterly publication, beginning in September, 1923. For the same reason, beginning with the January, 1924, issue, it became necessary to charge a subscription price. This covers approximately the cost of printing.

Pages are numbered consecutively throughout the year and an index to the complete report is included annually in the closing number.

Beginning with the 1930 issues, the activities and progress of the Geologic Branch are recorded also in these quarterly chapters. The important part that geology plays in the economic development of our mineral resources is further recognized in the change of title from *Mining in California* to California Journal of Mines and Geology, beginning with the January, 1933, chapter.

While current activities of all descriptions are covered in these chapters, the practice of issuing from time to time technical reports on special subjects will be continued as well. A list of such reports now available is appended hereto, and the names of new bulletins will be added in the future as they are completed.

The chapters are subject to revision, correction and improvement. Constructive suggestions from the mining public will be gladly received, and are invited.

The one aim of the Division of Mines is to increase its usefulness and to stimulate the intelligent development of the wonderful, latent resources of the State of California.

Types of Reports

In general the reports presented in these chapters are grouped into three classes:

1. Mines and mineral resources of a given county or area (describing kind, character, distribution and extent of development).
2. Specific economic and industrial mineral products (listing and describing the resources over the entire state of a given mineral substance, e.g., feldspar).
3. Geological reports on specific areas (recording results and conclusions with maps, derived from field studies; and tied in with economic possibilities and developments).

REPORTS OF DISTRICT MINING ENGINEERS

In 1919–1920 the Mining Bureau was organized into four main geographic divisions, with the field work delegated to a mining engineer in each district, working out from field offices that were established in Redding, Auburn, San Francisco and Los Angeles, respectively. This move brought the office into closer personal contact with operators, and it has many advantages over former methods of conducting field work, including lower traveling-expense bills for the Bureau's engineers. In 1923 the Redding and Auburn field offices were consolidated and moved to Sacramento.

The Redding office was reestablished in 1928, and the boundaries of each district adjusted. The counties now included in each of the four divisions and the location of the branch offices are shown on the accompanying outline map of the state. (Frontispiece.)

Reports of mining activities and development in each district, prepared by the District Engineer, will continue to appear under the proper field division heading.

REDDING FIELD DISTRICT

Chas. Volney Averill, Mining Engineer

There is no report from the Redding Field District on account of unfinished field work.

SACRAMENTO FIELD DISTRICT

C. A. Logan, Mining Engineer

On account of unfinished field work, there is no report from the Sacramento Field District in this issue.

SAN FRANCISCO FIELD DISTRICT

C. McK. Laizure, Mining Engineer

Reports covering the mines and mineral resources of all of the counties in the San Francisco Field District are now available, and field work at present is confined to investigations for special reports upon various economic minerals.

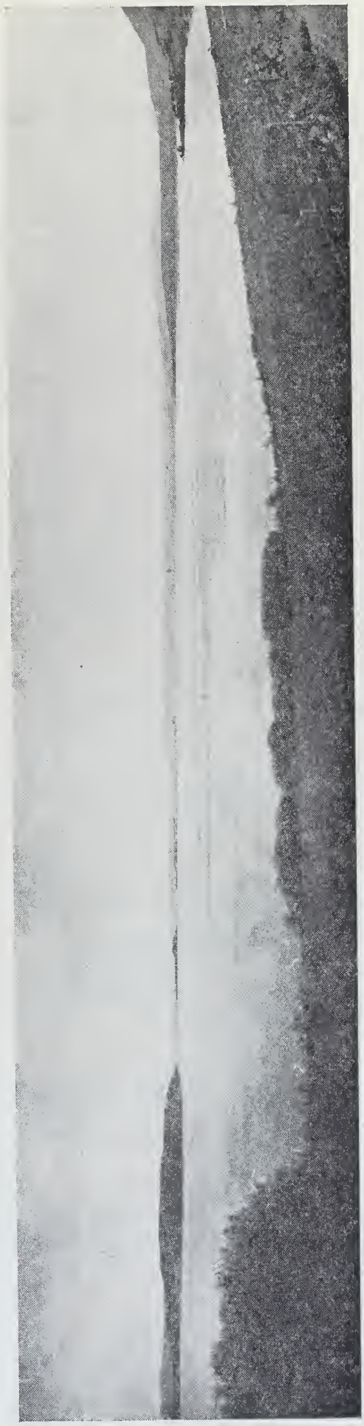


Photo by Walter W. Bradley

Mono Lake from the west side. Elevation 6,426 feet. Black Point at left; Black and Paoha Islands in left distance.

MINERAL RESOURCES OF MONO COUNTY

By R. J. Sampson, Assistant District Mining Engineer, and W. B. Tucker, District Mining Engineer

Mono County, comprising 3030 square miles, was formed April 24, 1861. It is bounded on the north and east by the State of Nevada, on the south by Inyo County and on the west by Madera, Tuolumne and Alpine counties. The county is extremely mountainous, the western portion lying in the Sierra Nevada, whose principal peaks rise to elevations of over 13,000 ft. The greater portion of the county, in its principal features, is a broad table-land at an altitude of from 5000 to 7000 feet above sea level, traversed by a series of approximately parallel ranges running northerly and southerly, which rise several thousand feet above the plateau. The other prominent ranges are the Sweetwater Mountains, along the eastern border of the county, in its northern portion, and the White Mountains crossing its extreme southeast corner.

While there are numerous small lakes in the Sierra Nevada, the only large body of water is Mono Lake which lies ten miles south of Bodie, at an elevation of 6426 ft. It covers approximately 1100 square miles. The water of this lake contains carbonate and sulphate of soda, sodium chloride, borax and other salts. A detailed description of this lake by I. C. Russell is contained in U. S. Geological Monograph XI, p. 267, 1885.

The principal streams are: The Owens River in the south which rises in the high peaks of the Sierra and flows southward, formerly emptying into Owens Lake but whose waters are now conveyed by an aqueduct as a supply for the City of Los Angeles, some three hundred miles south of its source; and the Walker River which flows northward into Nevada.

The Mono Basin project of the Los Angeles Bureau of Power & Light is designed to divert the waters of streams feeding Mono Lake from the west, into a tunnel under Mono Craters, into Long Valley Reservoir and to the upper reaches of the Owens River, thence to the Los Angeles aqueduct. It is hoped that a detailed description of this most interesting project, with the difficulties encountered in driving the long tunnel under the Mono Craters, will be printed as a special article, herewith.

Mining in the county dates from the discovery of the silver ores in Blind Springs Hill in 1862. The period of greatest activity was from 1876 to 1888. The most productive gold districts have been Bodie, Masonic, and Mono Lake. The principal production of silver has come from the Blind Spring Hill District near Benton and Silverado District, near Sweetwater.

The only railroad in the county is the narrow gauge branch line of the Southern Pacific which traverses the southeast corner of the

county for a distance of thirty miles, having its northern terminus at Benton. One of the principal paved highways of the state traverses practically the full length of the county from north to south. There is also a state highway from Leevining, across Tioga Pass into Yosemite Valley. Numerous mountain resorts attract many summer visitors, with the result that the scope of road improvement in the county is being continually extended.

GENERAL GEOLOGY

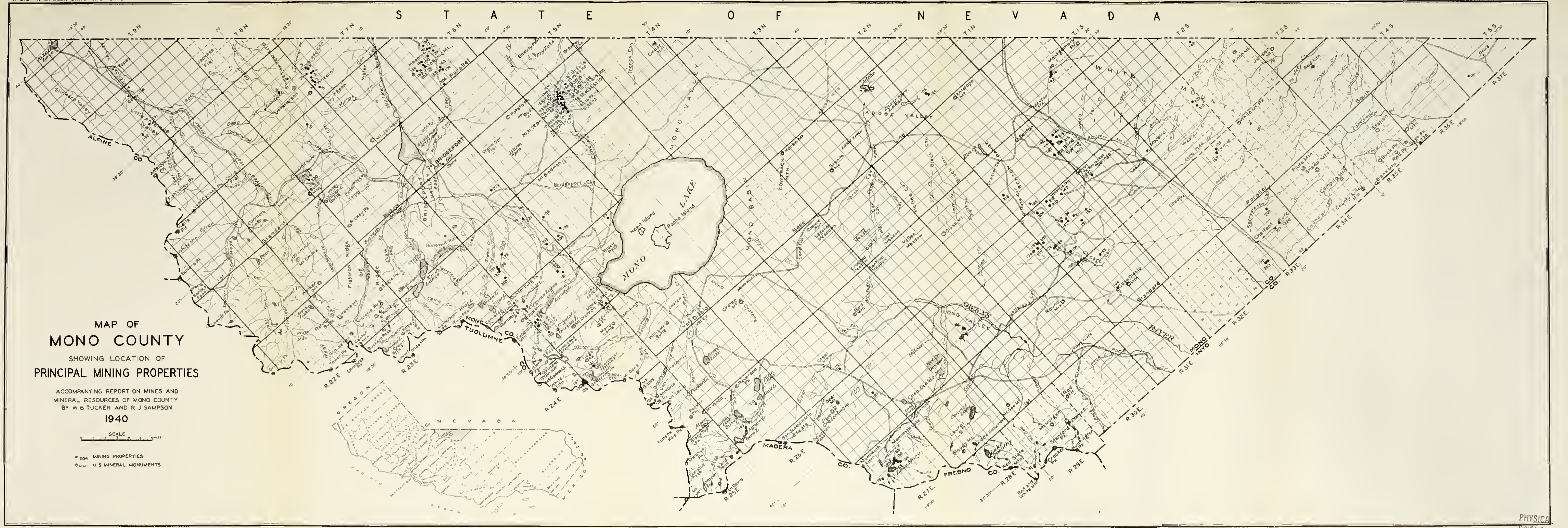
The Sierra Nevada, forming the western boundary of the county, from San Joaquin Peak to Topaz, is made up of deep-seated granitic rocks, including granites, diorites, granodiorite and gabbro; also metamorphic, crystalline rocks, including limestone, schists, slates, greenstones and quartzites. A belt of these metamorphic rocks, included in the granitic mass, extends from June Lake in a northerly direction to Virginia Creek. At its southern extremity, it is about 3 miles wide, while the northern end is some 6 miles in width.

The rocks of the central and major portion of the county are volcanic, consisting chiefly of andesites but including some basalt and small amounts of rhyolite. Blind Springs Hill, east of Benton, is composed of granitic type rock, in part, a coarsely crystalline hornblende-granite. This range is 6 miles long, north to south, by about 3 miles in width. To the east of this range, the White Mountains, forming the southeastern boundary of the county, are composed of sediments which have been intruded and metamorphosed by large masses of granite.

DIVISION OF MINES
WALTER W. BRADLEY, STATE MINERALOGIST

STATE OF CALIFORNIA
DEPARTMENT OF NATURAL RESOURCES
RICHARD SACHSE DIRECTOR

PLATE I.



ACCOMPANYING STATE MINERALOGIST'S REPORT XXXVI APRIL 1940

INDEX OF MINING CLAIMS

MONO COUNTY

A

No.	Name	Sec.	T.	R.
05	Accepted Lode	16	4N	27E
59	Addenda Lode	16	4N	27E
57	Adrian Lode	16	4N	27E
135	Ahwaga Lode	19–30	1N	24– 25E
105	Ajax Lode	16	4N	27E
147	Alderman Lode	18–19	2S	32E
25	Alleghaney Lode	16	4N	27E
171	Al Mono	24	8N	22E
143	Altamont Lode	20	2S	26E
146	Amherst	7–18	2S	32E
146	Amy	18–19	2S	32E
216	Andalusite Deposit (Champion Porcelain Co.)	13	3S	33E
220	Andalusite Deposit (Taylor)	13	3S	33E
146	Anderson Lode	18	2S	32E
96	Annex Lode	9	4N	27E
84	Anonyma Lode	9–16	4N	27E
125	Apex Lode	11–16	2N	25E
87	Arco Placer	20	4N	27E
50	Argentine Lode	9	4N	27E
103	Arthur Lode	16	4N	27E
67	Asia Lode	16	4N	27E
63	Australia Lode	16	4N	27E
131	Australian Lode	20	1N	25E

B

No.	Name	Sec.	T.	R.
207	Banner	18	3S	31E
21	Baltimore American	16	4N	27E
50	Bechtel Cons. Mining Co's Mines	9	4N	27E
9	Belle Lode	19–30	7N	25E
143	Bellevue Lode	17–20	2S	26E
92	Ben Butler Lode	10	4N	27E
137	Bevans Lode	24–10	1N	24E– 25E
93	Birdie Lode	21	4N	27E
82	Bishop Lode	16–21	4N	27E
146	Black Diamond	18	2S	32E
157	Black Eagle	3	4S	33E
119	Black Rock	16	4N	27E
165	Black Rock Tungsten	14–23	3S	31E
9	Blanket	10–36	7N	25E
146	Blind Springs Hill Cons.	18	2S	32E
94	Blue Bell Lode	16	4N	27E
172	Blue Bird Group	19	3S	31E
101	Blue Vein	26–21	4N	27E
48	Bodie	16	4N	27E
99	Bodie Placer	10	4N	27E
9	Boggs	10–30	7N	25E
22	Bonanza	16	4N	27E
146	Bonanza	7–18	2S	32E
74	Bonanza No. 3	16	4N	27E
173	Bonanza Group	32	3S	31E
140	Borasco	7–18	2S	32E
146	Brown	17–18	2S	32E
200	Brownie	29	5S	33E
174	Brownite Group	34	6N	26E
44	Bruce	9–16	4N	27E
146	Bryan	18	2S	32E
19	Bryant	17–26	4N	27E
86	Bryant Placer	20	4N	27E
9	Buck	19–30	7N	25E
9	Bulletin	19–30	7N	25E
15	Bullion	9–16	4N	27E
5	Bull Pine	31	7N	25E
81	Bullwhacker	16–17 20–21	4N	27E
43	Burgess	9–16	4N	27E
52	Burgess	16	4N	27E
146	Buscones	18	2S	32E

C

No.	Name	Sec.	T.	R.
144	California	18–19	2S	31E– 32E Unsur.
31	Captain Hasvil	16	4N	27E
164	Casa Diablo Quicksilver	21	1S	31E
113	Central	9	4N	27E
50	Central	9	4N	27E
120	Ceres	10	4N	27E
30	Challenge	16	4N	27E
53	Challenge	9–16	1N	27E
175	Charlston	36	2N	25E
159	Cheemung	28	6N	26E
195	Clinton Meyers	29	4N	31E
50	Clipper	9	4N	27E

C—Continued

No.	Name	Sec.	T.	R.
176	Clover Patch	13	3S 4S	30E– 31E
73	Cluff	21	4N	27E
9	Collins	9–30	7N	25E
147	Comanche	18	2S	32E
208	Comanche Group	24	2S	31E
109	Cooney Zinc	30	3N	25E
177	Conroy Ranch Placer	2	2N	26E
95	Contention	16	4N	27E
146	Cornucopia	18	2S	32E
142	Creek Side	27	1S	32E
154	Crescent	15–16	4S	27E
231	Crestview Pumice	35	2S	27E
20	Curry	16	4N	27E
7	Curve Slope	19–30	7N	25E
223	California Red Travertine	34	5N	25E
228	Crooked Creek Placers	30–31 6	5S 6S	36E

D

No.	Name	Sec.	T.	R.
35	Dale	16	4N	27E
33	Dearborn	16	4N	27E
36	Defiance	16	4N	27E
146	Diana	18	2S	32E
155	Dixie Queen	9–10	4S	27E
178	Dog Creek Placers	16–17 20–21	3N	25E
152	Don Quixote	9	4S	27E
42	Dudley	16	4N	27E
122	Dunderberg	19	3N	25E

E

No.	Name	Sec.	T.	R.
146	East Barasca	18	2S	32E
146	East Cornucopia	18	2S	32E
9	Eastman	19–30	7N	25E
77	East Noonday	16–21	4N	27E
9	Eclipse	19–36	7N	25E
47	Edith	9–16	4N	27E
97	El Dorado	20–21	4N	27E
179	El Dorado Group	17	4S	27E
138	Ella Bloss	15–16	1S	25E
139	Ella Bloss No. 2	15	1S	25E
147	Enterprise	13–18	2S	31E– 32E
103	Ethel Placer	19	3N	25E
145	Eureka	18	2S	32E
108	Euterpe	9–16	4N	27E
121	Eva	9	4N	27E
	Evening Star			

F

No.	Name	Sec.	T.	R.
78	Facto	16–17	4N	27E
51	First South Extension of the Bullion	9–16	4N	27E

G

No.	Name	Sec.	T.	R.
38	Gazelle	16	4N	27E
5	General Grant	31	7N	25E
1	Georgia Howell	30	7N	25E
46	Gildea	9–16	4N	27E
28	Glencoe	16	4N	27E
55	Glynn	16	4N	27E
180	Golconda	36	2N	25E
166	Gold Crown	16	3S	31E
125	Golden Eagle	2–11	2N	25E
182	Golden Gate	26	8N	22E
38	Golding	16	4N	27E
183	Gold Wedge	13	3S	30E
181	Goleta	11	2N	25E
75	Governor Stanford	16–21	4N	27E
144	Grand Central	13 18–19	2S	31E– 32E
9	Grand View	19–36	7N	25E
45	Granger	9–16	4N	27E
6	Grant	19–30	7N	25E
143	Gray Peak	20	2S	26E
1	Great Western	14	7N	24E
227	Golden Horseshoe	14	5S	33E
233	Gorella	19	2N	25E

H

No.	Name	Sec.	T.	R.
84	Harrington	9–16	4N	27E
84	Harrington Tunnel Claim	9–16	4N	27E
89	Hayward	16	4N	27E
152	Head Light	9–16	4N	27E
146	Helen B	18	2S	32E

H—Continued

No.	Name	Sec.	T.	R.
13	Hermine	15	6N	26E
110	Hobart	9	4N	27E
106	Homestake	16	4N	27E
9	Homestake Fraction	10–30	7N	25E
184	Homeview	15	6N	26E
9	Hope	19–30	7N	25E
185	Hornet Group	32	2S	31E
144	Hudson	13 18–16	2S	31E– 32E
211	Huebner	15	3S	31E
147	Hurrah	18	2S	32E

I

No.	Name	Sec.	T.	R.
146	Imogene	18	2S	32E
61	Inca	10	4N	27E
210	Independence	4	3S	31E
23	Insurance	16	4N	27E
126	Iron Mountain	11	2N	25E

J

No.	Name	Sec.	T.	R.
70	Johnson	17–20	4N	27E
12	Jump Up Joe	15	6N	26E

K

No.	Name	Sec.	T.	R.
147	Keller	18	2S	32E
2	Kentuck	30	7N	25E
146	Kerrick	18	2S	32E
77	Keystone	16–21	4N	27E
146	Keystone	18	2S	32E
212	King Group	4	3S	31E

L

No.	Name	Sec.	T.	R.
113	Lady Locke	9	4N	27E
132	Lake	24–19	1N	24E– 25E
186	Lake View	20	6N	26E
146	Last Chance	18	2S	32E
8	Last Chance	30	7N	25E
115	Laura	13–18	2S	31E– 32E
160	Legview	27	6N	26E
168	Lelda Group	19	3S	31E
213	Lemont Group	15	2S	26E
11	Liberty	21	6N	26E
187	Lisbon	13	3S	27E
158	Little Bodie Mining Co.	18	3N	26E
5	Livingston	31	7N	25E
111	Lizzie	16	4N	27E
127	Log Cabin Annex	36 1	2N 1N	25E
127	Log Cabin No. 2	36 1	2N 1N	25E
127	Log Cabin No. 6	30 1	2N 1N	25E
109	Lone Star	4	4S	31E
211	Lone Star	16	3S	31E
10	Long Street	3	6N	24E
14	Lost Horse	21	6N	26E
161	Lucky Boy	29	5S	37E
41	Lucky Jack	16	4N	27E
215	Lynford	18	2S	32E
224	Lowman Molybdenum	19	7N	25E

M

No.	Name	Sec.	T.	R.
151	Mammoth	9–10	4S	27E
37	Mammoth	16–17	4N	27E
9	Mammoth	19–30	7N	25E
147	Market	13–18	2S	31E– 32E
71	Mars	17–20	4N	27E
188	Mary B Group	32	3S	31E
92	Maryland	21	4N	27E
3	Maybelle	30	7N	25E
123	May Lundy	30	2N	25E
113	Midsummer	9	4N	27E
114	Midway	13 18–19	2S 2S	31E 31E
9	Midway No. 1	19–30	7N	25E
9	Mill King Nos. 1 to 8	19–39	7N	25E
9	Mill King	19–30	7N	25E
147	Mint	18	2S	32E
146	Modoc	13 18	2S	31E 32E
42	Molly	16	4N	27E
24	Monongahela	10	4N	27E
154	Monticello	15	4S	27E
153	Monte Cristo	15–16	4S	27E
5	Monte Cristo	31	7N	25E
84	Moonlight	9–16	4N	27E
146	Mountain View	18	2S	32E
232	Mono Lake & Spring Gulch Group	25	3N	25E

N

No.	Name	Sec.	T.	R.
140	Neptune	26–27	1S	32E
189	New Bodie	9	4N	27E
82	New Enterprise	16–21	4N	27E
9	New Homestake	19–30	7N	25E
50	Newton Booth	9	4N	27E
190	New York	21	6N	26E
128	Nioma No. 1	19	2N	25E
39	Noel	16	4N	27E
77	Noonday	16 20–21	4N	27E
69	Noonday	16–21	4N	27E
146	North Borasca	18	2S	32E
63	North Noonday	16	4N	27E
147	North Star	13 18	2S	31E 32E

O

No.	Name	Sec.	T.	R.
98	Oakland	20–21	4N	27E
50	Ohio	9	4N	27E
86	Old Dan	10 17–21	4N	27E
90	Olden	17	4N	27E
53	Omega	16	4N	27E
39	Omega	16	4N	27E
17	Osceola	9	4N	27E

P

No.	Name	Sec.	T.	R.
16	Packard	16–17	4N	27E
117	Packard Annex	16	1N	27E
72	Palfrey	17–20	4N	27E
124	Paraclete	2–11	2N	25E
191	Paragon Group	22	3S	31E
192	Parrett	19	2N	25E
210	Pat Reddy	19	2S	32E
94	Pearson	9–16	4N	27E
50	Pennsylvania	9	4N	27E
68	Persia	16	4N	27E
141	Phenix	20–27	1S	32E
83	Phenix	21	4N	27E
11	Pittsburg	15–16 21–22	6N	26E
62	Plute	16	4N	27E
140	Protection	18	2S	32E
9	Protection	19–30	7N	25E

Q

No.	Name	Sec.	T.	R.
155	Quien Sabe	6–10	4S	27E

R

No.	Name	Sec.	T.	R.
106	Ralston No. 1 North	9–16	4N	27E
170	Rancheria	29–30	3N	26E
117	Red Cloud	16	4N	27E
61	Red Jackel	16	4N	27E
114	Red Lyon	9	4N	27E
103	Red Rock	20	6N	26E
91	Relief	10	4N	27E
194	Reo Group	29	3S	31E
37	Republic	10–17	4N	27E
147	Rescue	18	2S	32E
102	Residium	16	4N	27E
9	Riches	19–36	7N	25E
147	Riley	18	2S	32E
40	Riqueza	16	4N	27E
201	Rough and Ready	22	6N	26E
197	Ruby Placer	19	3N	25E
143	Rush Creek	20	2S	26E
66	Russia	10	4N	27E
85	Russian	17–20	4N	27E
53	Rustler	16	4N	27E
234	Rattlesnake	30	3N	26E

S

No.	Name	Sec.	T.	R.
202	Sacramento	11	5S	33E
56	San Francisco	9	4N	27E
26	San Nicolas	16	4N	27E
29– 30	San Pedro	16	4N	27E
65	Scotia	16	4N	27E
35	Security	16	4N	27E
9	Sentinal	19–36	7N	25E
203	Serita	21	6N	26E
204	Sierra Vista	5	3S	31E
155	Silver Beauty	9–10	4S	27E
146	Silver Bell	18	2S	32E
146	Silver Cable	18	2S	32E
148	Silver Cons. Mining Claim	21–28	2S	34E
9	Silver King	19–36	7N	25E
56	Silver Queen	16	4N	27E
9	Silver Tip	19–30	7N	25E
217	Silver Reef	13	3S	30E
50	Sitting Bull	9	4N	27E

S—Continued

No.	Name	Sec.	T.	R.
76	Snowdrift	10–17 20–21	4N	27E
155	Snow Slide	10	4S	27E
34	Solano	16	4N	27E
133	Sonora	19	1N	25E
9	Sophia	19–30	7N	25E
167	Sour Dough	16	3S	31E
144	South End	13 18	2S	31E 32E
162	Southern Bell	35–36	5S	33E
205	Standard	16	4N	27E
6	Star	22	7N	24E
146	Steece	18	2S	32E
106	Stone Wall	9–16	4N	27E
206	Success	33	0N	26E
134	Summit	10–30	1N	25E
144	Super Six	13 18–19	2S	31E 32E
113	Sutro	6	4N	27E
229	Sierra	9–16	4S	27E
230	Silver Spray Quicksilver	30	6N	24E
127	Simpson	1 36	1N 2N	25E

T

No.	Name	Sec.	T.	R.
196	Thomas Hoyle	20	1N	31E
163	Tioga	9	4N	27E
115	Tioga South	6	4N	27E
132 to 137	Tioga Group		1N	24E 25E
147	Tip Top	18	2S	32E
149	Tower	3	3S	31E
199	Tripoli	10	5S	33E
226	Twenty Grand	14	5S	33E

U

No.	Name	Sec.	T.	R.
91	University Gold	21	4N	27E
79	University First North Ex- tension	21	4N	27E
104	Uranus Placer	10–15	4N	27E

V

No.	Name	Sec.	T.	R.
58	Virginia	16	4N	27E
63	Virginia	16–21	4N	27E
156	Vulcanite	2	4S	33E
153	Vulcanus	2– 3	4S	33E
157	Vulcanus Nos. 8 and 9	3	4S	33E
221	Virginia Creek Placers	2–11 12	3N	25E

W

No.	Name	Sec.	T.	R.
130	Wasatch	19	2N	25E
140	Wasatch	18	2S	32E
107	West Bullion	9–16	4N	27E
112	West Maryland	21	4N	27E
109	Whitney	10	4N	27E
218	Wild Rose	19	2S	31E
225	Wederiz Quicksilver	26	4N	25E

Y

No.	Name	Sec.	T.	R.
147	Yaqui	18	2S	32E
27	Yerington	16	4N	27E
222	Yellow Jacket Pumice	6– 8 7–17	3S	32E
129		19	2N	25E

MINERAL PRODUCTION OF MONO COUNTY, 1880-1938

Year	Gold, value	Silver, value	Lead		Lime		Miscellaneous and unapportioned		
			Pounds	Value	Barrels	Value	Amount	Value	Substance
1880	$2,407,236	$582,905							
1881	3,385,000	300,000							
1882	2,200,000	380,000							
1883	1,750,000	290,000							
1884	1,000,000	285,000							
1885	482,860	91,849							
1886	439,558	163,502							
1887	382,498	118,945							
1888	297,000	75,000							
1889	193,264	86,827							
1890	144,180	52,293							
1891	302,415	18,983							
1892	396,296	271,058							
1893	293,637	11,401							
1894	358,824	11,549	50,000	$1,500					
1895	552,690	84,910	94,400	2,926			800 cu. ft.	$8,000	Onyx.
1896	451,553	82,283	73,500	2,205	500	$2,000	3,000 cu. ft.	24,000	Onyx.
1897	520,101	72,491	32,000	1,088	1,200	4,800			
1898	446,017	66,667	75,000	2,737	3,000	4,000			
1899	697,069	47,547	28,000	1,190	1,200	3,750			
1900	670,200	75,921	50,000	2,000	1,100	4,000			
1901	493,355	25,091	29,900	1,160	2,000	3,000	1,938 lbs.	305	Copper.
1902	510,596	36,548	4,400	154	2,000	2,000			
1903	334,713	20,067	1,000	36	1,818	5,000	1,600 lbs.	208	Copper
1904	268,930	2,955			215	850			
1905	308,884	11,240							
1906	338,698	13,151							
1907	383,971	29,797							
1908	413,946	26,134					7,100 gals.	5,575	Mineral water.
1909	354,909	37,792						106,772	Unapportioned, 1900-1909.
1910	435,724	93,391							
1911	261,232	35,508	37,000	1,665					
1912	377,518	70,602	23,936	1,077	4,961	3,721	8,179 lbs.	1,350	Copper.
1913	147,271	23,263			2,135	1,600	79,319 lbs.	12,294	Copper.
1914	7,000	10,000					1,000 lbs.	150	Salt.
1915	107,302	1,923						200	Other minerals.
1916	237,084	3,606						300	Other minerals.
1917	209,040	5,662	1,912	164				3,906	Copper, molybdenum, salt.
				Totals	20,129	$34,721			
					Miscellaneous stone, value				
1918	31,252	22,727	1,318	94			160 lbs.	40	Copper.
								750	Other minerals.
1919	29,428	55,558	1,556	82			539 lbs.	100	Copper.
1920	144,746	34,369	85,014	6,801		$1,000	3,215 lbs.	592	Copper.
								750	Other minerals.
1921	37,754	15,160	42,962	1,933			2,940 lbs.	379	Copper.
								1,650	Onyx and salt.
1922	65,747	11,686	9,820	540			4,338 lbs.	586	Copper.
								8,304	Other minerals.
1923	34,661	3,120				10,000		45,010	Other minerals.
1924	49,651	6,472	32,458	2,597		19,044		48,927	Other minerals.
1925	5,503	1,590	22,488	1,957		29,250		146,300	Other minerals.
1926	20,204	121,404	20,906	1,672			2,628	368	Copper.
								66,200	Other minerals.
1927	3,686	21,822	4,830	304				76,375	Other minerals' clay, copper, pumice, salt, andalusite, miscellaneousstone.
1928	6,307	176,115						31,998	Clay (pottery), pumice, volanic ash, salt, travertine.
1929	10,025	28,137	19,602	1,235		15,257	16,552 lbs.	2,913	Copper.
								161,263	Andalusite, clay (pottery), pumice, volcanic ash, salt.
1930	26,234	3,166				19,770	2,006 lbs.	216	Copper.
								99,553	Andalusite and pumice.
1931	125,342	5,372	137	5		48,259		23,945	Pumice and salt.
1932	26,333	5,292	33,401	1,002		64,942	3,970 lbs.	250	Copper.
								37,861	Andalusite and pumice.

MINERAL PRODUCTION OF MONO COUNTY, 1880-1938—Continued

Year	Gold, value	Silver, value	Lead		Lime		Miscellaneous and unapportioned		
			Pounds	Value	Barrels	Value	Amount	Value	Substance
1933	33,378	1,004	5,537	170	--------	20,354	665 lbs.	43	Copper.
							----------	26,198	Andalusite and pumice.
1934	56,092	20,205	7,487	277	--------	77,806	510 lbs.	41	Copper.
							----------	58,017	Gems (rutile), molybenum ore, pumice, salt, andalusite.
1935	39,994	72,634	6,305	252	--------	--------	1,295 lbs.	107	Copper.
							----------	38,032	Miscellaneous stone.[1]
							----------	72,729	Unapportioned.
1936	64,120	329,245	16,805	773	--------	--------	6,748 lbs.	621	Copper.
							----------	18,452	Miscellaneous stone.[1]
							----------	85,640	Pumice, andalusite.
1937	182,105	488,347	12,938	763	--------	--------	13,216 lbs.	1,599	Copper.
							----------	87,253	Miscellaneous stone.[1]
							----------	44,858	Unapportioned.
1938	117,390	142,854	6,039	278	--------	--------	3,050 lbs.	299	Copper.
							----------	4,121	Miscellaneous stone.[1]
							----------	84,574	Andalusite, pottery clay, pumice, tungsten.
Totals	$23,670,523	$5,098,111	829,751	$38,637	--------	$305,682	----------	$1,465,786	

[1] Includes crushed rock, rubble, rip-rap, sand, gravel.

MINERAL RESOURCES

Among the minerals which have been produced commercially in the county are andalusite, barite, clay, copper, dolomite, gold, lead, limestone, molybdenum, pumice, salt, silver, travertine, tungsten and zinc.

METALS

COPPER

Copper occurs in association with other metallic minerals in the county, notably in the well mineralized belt in the Sierra Nevada. Spasmodic attempts at mining this metal have been made. The principal occurrences are on Copper Mountain, sixteen miles southwest of Bodie and four miles from the west shore of Mono Lake. In this area copper ores are found on the contact of limestone and porphyry, and consist principally of azurite, cuprite, malachite and chrysocolla. No development work has been done on these deposits since 1908 and their extent has never been determined. The antimonial-silver ores of Blind Springs Hill carry some copper in the form of azurite, malachite, tetrahedrite and chalcopyrite.

GOLD

The principal production of gold in Mono County has been from the Bodie, Masonic, Lundy, and Mono Lake districts. The Bodie Mining District has been the most important in Mono County and has a production record of about $30,000,000 since its discovery in 1860. In this district the Standard Consolidated Mining Company's record of production from 1877 to 1913 was $18,202,855, of which $5,264,407 was paid in dividends. This property is producing now. The Southern Consolidated, which comprised the Noonday, Red Cloud, Addenda, Oro and Defiance mines, produced from 1877 to 1888, $1,048,372. The

Syndicate Mine produced over $1,000,000. The most productive mine in the Masonic District was the Pittsburg-Liberty, with a record of $700,000. Other important producing mines have been the Casa Diablo, located in the Chidago District, and the Mammoth Mine, near Mammoth in the high Sierra. Present-day developments indicate that the Simpson Mine, about 5 miles west of Leevining, will become an important producer.

The principal gold placer areas of the county are on the headwaters of the Walker River, also Virginia and Dog creeks and the Bodie Diggings, located north of Mono Lake.

MINES

Al Mono Mine is in the West Walker River Mining District, in T. 8 N., R. 22 E., M. D. M., 3 miles south of Coleville. Idle.

Bibl.: State Mineralogist's Report XV, p. 165.

Casa Diablo Mine, comprising 6 claims, is in the Casa Diablo Mining District, 22 miles north and a little west of Bishop; elevation 7200 ft.; owner, William Birchim, Bishop, Calif.

Three parallel veins occur in the granite. They are known as the May Brooks, Don of Hope and Dry Bone. They strike N. 55° E. and dip 65° NW. The widths vary from 12 in. to 3 ft. The quartz filling is stained with iron oxide and carries but a small percentage of pyrite. The most productive vein has been the May Brooks.

Development consists of a number of tunnels driven at different elevations. The main tunnel was driven as a crosscut S. 30° E. 1000 ft., intersecting the above-mentioned veins. The May Brooks vein was cut at 300 ft. from the portal and drifts were driven 300 ft. SW. and 75 ft. NE. In the southwest drift, 250 ft. of its length was stoped to the surface. At 390 ft. from tunnel portal, the Don of Hope vein was encountered. A drift was driven on it 300 ft. to the northeast, 100 ft. of which was stoped. On the Don of Hope vein, about 30 ft. southwest of the crosscut, a winze was sunk 250 ft. The Dry Bone vein was cut about 100 ft. from the Don of Hope. Ore is reported to have averaged $12 per ton.

In late years only a little intermittent leasing has been done. Idle.

Bibl.: State Mineralogist's Reports XVIII, p. 418; XXIII, pp. 377-378.

Charlestown Mine, comprising 8 claims, is located in Sec. 36, T. 2 N., R. 25 E., M. D. M., in the Mono Lake Mining District; elevation 8700 ft.

A quartz vein occurs in slate, strike NW., dip vertical; width 5 ft. The values are free milling.

Development consists of crosscuts and tunnels amounting to 900 ft. Idle.

Bibl.: State Mineralogist's Reports VIII, p. 385; XII, p. 177; XIII, p. 227; XV, p. 172.

Chemung Mine, comprising one claim, is 2½ miles southeast of the town of Masonic, in the Masonic Mining District; elevation, about

8600 ft.; owner, *Masonic Mining Trust,* Geo. B. Burris, Oakland, Calif.; under lease to Conrad G. Munro, 323 W. 6th St., Los Angeles.

The development work on this property (all inaccessible at the time it was visited) consists of a vertical shaft, 200 ft. in depth, with drifts on the 50, 100 and 200-ft. levels. The present lessee had made no attempt to get into the mine but had built a camp and erected the following described mill for the purpose of milling the dumps: 9 in. by 12 in. jaw crusher, elevator to bin, belt feeder to 4 in. by 6 in. jaw crusher, to 4 ft. by 3 ft. Hendy ball mill to Dorr type, Simplex classifier to two 12 ft. by 12 ft. agitators, arranged for counter current decantation; to two 30 ft. by 8 ft. Dorr thickeners; decanted solution to zinc boxes; capacity 20 tons per day.

Power for mill is furnished by 4-cylinder, semi-diesel engine. A 20-h.p. gas engine runs crusher elevator and mine pump. Water is obtained from a spring about 600 ft. south of the mill. Twenty men employed (April, 1937) building camp and mill.

Operations were discontinued later in 1937 or early in 1938 and the property has been idle since that time.

Bibl.; State Mineralogist's Reports XVIII, pp. 415-416; XXIII, p. 378.

Clover Patch, Gold Lode, B. B. and Old Glory Groups, comprising 52 claims, are situated in T. 3 and 4 S., R. 30 and 31 E., in the Clover Patch and Chidago mining districts, 35 miles north of Bishop and 14 miles southwest of Benton; elevation 7000 to 8500 ft.; last known owner, *Universal Ore Milling & Mining Co.,* Dr. E. W. Ames, president; office in Reno, Nev.

These claims are located along a series of quartz veins, roughly parallel, which strike N. 30° W. and they extend from the Casa Diablo Mine to Wildrose Canyon. The country rock is granite, rhyolite and quartzite, with some interspersed limestone.

Development consists of a number of opencuts, shallow shafts and short tunnels. Idle.

Bibl.: State Mineralogist's Report XXIII, pp. 378-379.

Conroy Ranch (placer), comprising 400 acres of patented land, is on the north shore of Mono Lake and west of Mono Diggings; owner, Richie Conroy, Mono Lake, Calif.

It is reported that this ranch was drilled as prospective dredging ground, results showing an average of 25 cents per yard over the entire area. Idle.

Crooked Creek Placers are in Sec. 19, 30 and 31, T. 5 S., R. 36 E., 12 miles northwest of Deep Springs Ranch, on the west slope of the White Mountains; elevation 8000 ft.

In about 1933 some two miles of north-south channel were located by W. H. McCarthy, the Beauregard brothers and H. W. Van Loon, all of Bishop. These locations extended north from Crooked Creek to Cottonwood Creek. It is along the west side of Iron Peak, one mile northwest of which it swings northwest toward Cottonwood Creek. It is partially capped with lava flows. The width of the channel is 400 to 600 ft. The rim rock is granite, capped with basalt and andesite.

The gravel, consisting of slate, quartzite, granite and quartz, shows on the ridges 500 ft. above the creek. It is not cemented and contains boulders up to 8 in. and 10 in.

Development consists of short tunnels and shallow shafts, driven at various elevations above both North and South of Crooked Creek. One tunnel was driven 112 ft. Gravel from all of these workings pan colors, from 2¢ to 5¢ in size.

The property was under option to L. E. Hanchett, of San Francisco, from 1937 to 1939, who sunk some additional test pits. Idle.

Dog Creek Placers (see Virginia Creek).

Dunderberg Mine is situated one mile south of Green Creek, in Sec. 19, T. 3 N., R. 25 E., M. D. M.; owner, J. S. Cain, Bodie, Calif.

D. V. Cain, of Bridgeport, has just completed pumping out the workings and reports a 5-ft face of ore, presumably in a drift from the 100-ft. winze sunk from the lower tunnel, which is 1700 ft. in length.

Bibl.: State Mineralogist's Reports XII, p. 178; XIII, p. 227; XV, pp. 166-167; XXIII, pp. 379-380.

El Dorado Group of claims is in the Mammoth Lakes Mining District, 4 miles southwest of Mammoth Lakes P.O.; elevation 9400 ft.; last known owners, D. F. Shively and associates, Mammoth, Calif.

The vein, 8 ft. in width, has a diorite-porphyry hanging wall and a quartzite footwall. Its strike is NW. and it dips 80° NE. Development consists of shallow shafts and opencuts along the vein.

Evening Star Group of 10 claims is in the Chidago District; owners, Joe Riley, Elmer Summers and H. M. Brown, of Bishop, Calif.

A series of north-south quartz veins occurs in rhyolite. There is also a system of east-west veins; dip 35° to 40° S.; width 2 ft. to 4 ft. A tunnel has been driven west 600 ft. in the footwall rhyolite without cross-cutting the vein. About 1000 feet west of this tunnel, is a 50-ft. tunnel driven on a vein in granite; strike E.-W., dip N.; width 12 in.; also a 40-ft. shaft. Ore on the dump from these workings is said to carry from $6 to $20 in gold. Idle.

Gold Crown Mine, comprising 1½ claims, is in the Indian Mining District, 12 miles south of Benton and 10 miles west of Hamil, a station on the Southern Pacific Railroad; elevation 8000 ft.; owner, Joseph Main, Benton, Calif. The property is leased to *Mineral Reduction Co.,* C. W. Jones, president, 337 West Ave. 26, Los Angeles.

The country rock is quartz monzonite. The vein has a N.-S. strike and dips 70° W. Vein-filling is brecciated quartz and altered country rock. Width is 10 ft. to 20 ft.; mineralization, free gold and iron pyrite. Values are reported to vary from $2 to $30.

Development consists of three tunnels. On the north side of the gulch a tunnel has been driven 120 ft. At the portal a shaft has been sunk to a depth of 45 ft. On the south side of the gulch there is a 70-ft. tunnel, with a 20-ft. winze. About 40 ft. below is a 300-ft. tunnel. At approximately 200 ft. from the portal, there is a 78-ft. winze with a drift at the bottom 100 ft. south and a 30-ft crosscut west.

Leasers are shipping about 10 tons per day to the mill at Benton from upper tunnel on south side of the gulch. Three men are working.

Gold Wedge Mine, comprising 14 claims, is on the east slope of the Benton Mountains, 11 miles southwest of Benton; elevation 7000 ft.; owner, Joseph Main, Benton, Calif.

Two systems of veins here occur in the schist. One strikes N. 20° E. and dips 50° W. The other strikes E. and dips N. The vein-filling is quartz mineralized with pyrite, galena, marcasite and carries values in gold and silver. The veins vary from 2 ft. to 4 ft. in width.

Development consists of a tunnel driven south 175 ft. at an elevation of 7100 ft. This was driven on the N. 20° E. vein. At 150 ft. from the portal, the tunnel intersected an east-west vein and a drift was driven 40 ft. east on it. This vein was 18 in. in width. It is reported that 84 tons of ore shipped from these workings carried 50 oz. in silver and 0.4 oz. in gold. Three hundred feet below these workings a crosscut tunnel has been driven south 900 ft. This tunnel is inaccessible due to caving. On the north side of the gulch a shaft has been sunk 135 ft. with a 100-ft. drift to the southwest at the bottom. Idle except for assessment work.

Bibl.: State Mineralogist's Report XXIII, pp. 380-381.

Golden Horse Shoe Group of 3 claims is on the ridge north of Piute Canyon, on the west slope of the White Mountains, about 10 miles northeast of Laws; elevation 6500 ft.; owners, Joseph Smith and Wm. Ray, Laws, Calif.

A quartz vein in the schist, from 2 ft. to 4 ft. wide, strikes NE., dips NW. A tunnel has been driven 150 ft. northeast on this vein. This tunnel is 200 ft. above the bottom of the canyon. At 50 ft. above another tunnel has been driven northeast 140 ft. on the vein. There are other short tunnels and shallow shafts on the property. Idle.

Golconda Mine is in the S½ of Sec. 36, T. 2 N., R. 25 E., M. D. M., in the Mono Lake District, on the east slope of the range west of Mono Lake; owner, *Nevada-California Power Co.* Idle.

Bibl.: State Mineralogist's Report XV, p. 172.

Golden Gate Mine is in Sec. 26, T. 8 N., R. 22 E., M. D. M., in Rodriguez Canyon, about 3 miles from Coleville; present owner unknown.

There are two quartz veins in the schist; strike N. 60° E., dip 38°. They vary in width from 2 ft. to 4 ft. Development consists of 5 tunnels from 300 ft. to 1800 ft. in length. Idle.

Bibl.: State Mineralogist's Report XV, pp. 140-142 and p. 165.

Goleta Mine, comprising 7 patented claims, is in Sec. 11, T. 2 N., R. 25 E., M. D. M., on the eastern slope of the Sierras, about 6 miles northeast of Lundy; elevation 7500 to 8500 ft.; last known owner, Goleta Consolidated Mining Co.

The property has been developed by two tunnels. The upper tunnel is 1200 ft. long and the lower is said to be 500 ft. in length. The vein quartz carries values in gold, silver and copper. Idle.

Bibl.: State Mineralogist's Reports XII, p. 178; XIII, p. 228; XV, p. 172.

Gorilla Mine is an old property in the Homer Mining District, in the Sierra Nevada Mountains, on the south side of Mill Creek, about one mile west of Lundy and 8 miles west of Mono Lake; elevation about 9000 ft.; present owner unknown.

According to our old reports, this vein occurs in hornblende granite. Its strike is N. 40° W., dip about 50° SW., having an average width of 2 ft. It was developed by three tunnels which in 1888 were reported to be 270, 340 and 412 ft. long, respectively. The shortest tunnel, No. 1, is the upper one, but a short distance below the outcrop. No. 2 is 54 ft. below No. 1 and near its portal is connected with No. 3 tunnel by a 386-ft. shaft. It is probable that some of these tunnels have been extended as rumor places the production at $360,000, whereas, the secretary of the company which operated the property gave the production as $61,773, all produced in the years, 1882 to 1886. It was known to have had a small production in the summer of 1887. Idle.

Bibl.: State Mineralogist's Report VIII, pp. 370-371.

Headlight (see Monte Christo).

Hermine Mine, consisting of one claim, is in the Masonic Mining District, in Sec. 15, T. 6 N., R. 26 E., M. D. M.; last known owner, Mrs. Homer Grigsby, Masonic, Calif.

Bibl.: State Mineralogist's Report XV, p. 164.

Home View Mine is in the Masonic District, in Sec. 15, T. 6 N., R. 26 E., M. D. M., north of the Pittsburg-Liberty Mine. A tunnel is driven south 900 ft. in granite. Idle.

Bibl.: State Mineralogist's Report XV, p. 164.

Hornet Group of Mines is 8 miles southwest of Benton, in the Benton Mountains, south of the Tower Mine. It was formerly known as the Yellow Jacket Mine; elevation 6350 ft.; owners, Harry M. Brown and J. F. Birchim, Bishop, Calif.

The main Yellow Jacket vein strikes N. 30° E.; dip vertical; width 2 ft. to 4 ft. It occurs on a granite-schist contact. There is also a vein in the granite; strike E.-W.; dip 50° N. It is 2 ft. wide.

Development consists of a 150-ft. shaft and a number of short tunnels and shallow shafts. Idle.

Lakeview Mine, comprising 4 claims, is in the Masonic Mining District, about one-half mile north of the Chemung Mine and about 7 miles northeast of Bridgeport; elevation 8200 ft.; owner, J. M. Laughlin, Bridgeport, Calif.; under lease to E. A. Montgomery, on the ground.

There are two parallel veins in the rhyolite country rock; strike N. 80° E.; dip 45° SE. These veins are approximately 160 ft. apart. They vary in width up to 25 ft.

Development consists of three tunnels and a series of open-cuts. The lower tunnel on Lake View No. 2 Claim is 350 ft. long. Lake View No. 1 tunnel is about 300 ft. long and the Anaconda tunnel is some 250 ft. in length. Present lessee is sinking a vertical, 2-compartment shaft on the southernmost vein. In September, 1939, this shaft was down about 30 ft. Four men are working.

Bibl.: State Mineralogist's Reports XV, pp. 164-165; XXIII, p. 381.

Last Chance Mine, comprising 6 claims, is in the Chidago District, about 1½ miles south of the Lone Star Mine; elevation 6500 ft.; owner, Jack Irwin, Bishop, Calif.

A vertical quartz vein from 6 in. to 12 in. wide here occurs in the schist; strike N. 70° E. There is also a northwest-southeast vein about 6 in. wide which dips 38° NE. On this vein a tunnel has been driven southeast 100 ft., where it cut a northeast-southwest vein. A winze is sunk 75 ft. on the intersection, with three levels. On the 50-ft. level drift E. 150 ft., W. 100 ft.; stoped a length of 150 ft.; average width of ore 8 in. Shipments aggregating 300 tons, averaged 1.85 oz. of gold per ton.

Equipment consists of 110-cu. ft., portable compressor, air operated hoist and tugger on the winze. Idle.

Leida Group of Mines is 2 miles west of Deer Springs and 12 miles southwest of Benton, in the Benton Mountains and in the Chidago Mining District; elevation 8000 ft.; last known owner, Louis Leida, Benton, Calif.

A series of parallel veins occur in the granite, strike NW. and dip 50° SE. They vary in width from 3 ft. to 6 ft. Development consists of a number of short tunnels and opencuts along the outcrop. Idle.

Lisbon Mine, comprising 8 claims, is on the ridge northeast of Mammoth Creek, in the Mammoth Lakes Mining District, about 5 miles southwest of Mammoth Post Office; elevation 9500 ft.; owners, Earl C. Dart and Frank Butler, Mammoth, Calif. This, with the Mammoth Mine, was one of the original producers from 1878 to 1884.

The vein is from 2 ft. to 6 ft. wide, strikes N. 30° E. and dips 70° SE. It was developed by three tunnels about 100 ft. apart. It is stated that the Lisbon vein faults the Mammoth vein. The ore was free-milling with some auriferous pyrite. It was formerly treated in a 5-stamp mill located below No. 3 tunnel. The workings are caved.

Little Bodie Mining Co., Geo. De Wolfe, president, Sixth and F Sts., Chula Vista, Calif., has 5 claims about 10 miles southeast of Bridgeport and 4 miles east of the highway; elevation about 8000 ft.

A quartz vein in diorite strikes N. 60° E.; dip 60° NW.; width 2 ft. to 4 ft. Values are largely in sulphides, with a little fine, free gold. Values are said to be $12 per ton.

Development consists of 175 ft. inclined shaft, with levels at 100 and 150 ft. On 100-ft. level drift northeast 60 ft., on 150-ft., drift northeast 135 ft. It is reported that these workings are in ore and that the full length of the shoot has not yet been determined. About 260 ft. northeast of the shaft, there is an interesting vein; strike NW.-SE. Operators plan to extend the 150-ft level to this intersection.

At the shaft, the following described mill was in course of construction: Bin to jaw crusher to 4 ft. by 4 ft. ball mill, drag classifier and 3 Kraut flotation cells. The capacity is about 30 tons per day. Seven men are working erecting mill.

Lost Horse Mine, consisting of one claim, is in Sec. 20, T. 6 N., R. 26 E., M. D. M., in the Masonic Mining District; last known owner, J. D. Martin, Masonic, Calif.

There is a shaft 50 ft. deep; also trenches along an iron-stained outcrop of quartzite. Idle.

Bibl.: State Mineralogist's Report XV, p. 164.

Lucky Boy Mine (Piper), comprising 4 claims, is on the west side of Fish Lake Valley, 1½ miles north of Cottonwood Creek, about 2 miles west of Oasis; elevation 5700 ft.; owners, James Barrett, Oasis, Calif., and Geo. Smith, Beaumont, Calif.

A quartz vein in granitic porphyry, strike N. 65° W., dip 30° to 45° SW., varies from 2½ ft. to 5 ft. in width. Vein filling consists of from 3 in. to 10 in. of quartz and altered country rock; mineralization galena, hematite and free gold. Development consists of two tunnels. Upper tunnel is 190 ft. long, with a stope 4 ft. wide and 90 ft. long; also a winze about 35 ft. deep at 60 ft. from the portal. The lower tunnel is 35 ft. below the upper tunnel and is connected with it by a raise. The mill is one and a half miles south of the mine, on the north side of Cottonwood Creek. It consists of a small jaw crusher; three 1250-lb. stamps; and two 5-ft. by 8-ft. plates. Power is furnished by 15-h.p. gas engine. Idle.

Mammoth Mine, comprising 26 claims, is in Sec. 9, 10, 15 and 16, T. 4 S., R. 27 E., 4 miles southwest of Mammoth P. O., on the east slope of the Sierra Nevada; elevation 9,000 to 10,000 ft. The claims are owned by the Bank of California, San Francisco; Chas. F. Pugh, Oakland; Jas. F. Birchim, Bishop; Geo. G. Young, Oakland; R. D. Owen, Ojai; Fred N. Smith and Robert Kelso, Bishop, Calif. They are all under option to Chas. F. Pugh, Oakland, Calif.

Holdings formerly comprised 5 claims known as Folk, Armstrong, San Francisco, Big Bonanza and Mammoth. The property was operated by the Mammoth Mining Co. from 1878 to 1881, with a production of $200,000 in gold.

The vein occurs in a siliceous, crystalline rock, probably resulting from the alteration of slate. The strike is generally northwest, dip 70° to 80° NE. Its outcrop shows it to be over 100 ft. wide, in places, while old reports state that the ore is from 14 ft. to 40 ft. wide. The vein filling is quartz and decomposed wall rock.

The property is developed by four tunnels. The lower tunnel (No. 4), at an elevation of 8900 ft., was driven N. 35° W., 1650 ft. At 465 ft., there is a crosscut S. 55° W., 87 ft. said to be all in quartz, without having reached the footwall. At 1105 ft., there is a crosscut S. 55° W., 50 ft. There are other workings in this tunnel (which is inaccessible), description of which is not available. Tunnel No. 3, at an elevation of 9275 ft. has been driven 1250 ft. with a 50-ft. crosscut at about 470 ft. from the portal. Tunnel No. 2 at 9475 ft. elevation is 600 ft. long. Tunnel No. 1, elevation 9600 ft., is about 300 ft. long and some 600 ft. below the top of the mountain. These working are all inaccessible and the figures are taken from old reports and maps.

The lessee has six men sampling outcrops to determine whether he will reopen the old tunnels.

Bibl.: State Mineralogist's Reports VIII, pp. 373-375; XXIII, pp. 384-385.

Mammoth Consolidated Mines (Crystal Craig Mining Co.), comprising 27 claims, adjoins the Old Mammoth on the northeast and is one mile south of Lake Mary; elevation 9200 ft.; owner, Mammoth Mines Corp.; under lease to *Crystal Craig Mining Co.,* Perry Elswick, secretary, 240 N. Irving Blvd., Los Angeles.

The country rocks are diorite porphyry and belts of crystalline rocks to the north and south of Mammoth Creek, with granodiorite on the south. The ridge is capped with andesite. The mineralization is confined to a belt of the crystalline rocks which is about 500 ft. wide and has a general northwest strike. The gold values are found along northwest fractures in this rock. Mineralization consists of pyrrhotite, pyrite, sphalerite and some chalcopyrite.

Principal development consists of two tunnels. Upper tunnel is a crosscut driven east 65 ft. to the vein; drift north 250 ft., 200 ft. of which is reported to be in ore. Where crosscut cuts the vein, there is a raise from the lower tunnel which has been driven 25 ft. above the upper tunnel. At one place in this tunnel, crosscuts indicate a mineralized width of 25 ft. The lower tunnel, approximately 100 ft. below the upper one, is a crosscut east 40 ft. to the vein; drift southeast 480 ft. At 280 ft. from crosscut there is another crosscut northeast 50 ft. and another crosscut northeast 20 ft. at 180 ft. At 360 ft. from the main crosscut there is a raise connecting with upper tunnel.

About 280 ft. northeast of this vein is the Dome vein roughly parallel, which shows on surface up to 20 ft. in width. No work has been done here.

On the Argosy group, about 3000 ft. south of the above described workings and just north of Mammoth Creek Falls, a tunnel has been driven 150 ft. on a vein 6 ft. to 8 ft. wide. On the west side of the creek, two crosscuts 50 ft. and 75 ft., are reported to carry values throughout. Definite average values were not obtainable.

At the portal of the lower tunnel of the main workings, the following described mill has been erected: Jaw crusher 9 in. by 16 in., elevator to 100-ton bin, reciprocating feeder to 5 by 5 ball mill, Dorr type classifier, centrifugal pump to 4 ft. by 16 ft. plates, to 2 Wilfley tables; all driven by 110-h.p. diesel engine.

There is also a camp and complete assay laboratory on the property. Idle.

Bibl.: State Mineralogist's Reports VIII, pp. 373-375; XXIII, pp. 384-385.

Mary B. Group of 4 claims is situated in the Chidago Mining District, in the Benton Mountains, 12 miles southwest of Benton; owners, Harry Brown and J. F. Birchim, Bishop, Calif.

The country rock is rhyolite. A quartz vein 4 ft. to 6 ft. wide strikes E. and dips 60° N. The only development consists of shallow shafts and opencuts on the vein outcrop. Idle.

May Lundy Mine (Crystal Lake). It comprises 20 claims, one of which is patented, situated on the south slope of Mt. Snowdin, in Sec. 30, T. 2 N., R. 25 E., M. D. M., 5 miles south of Lundy and 6 miles west of Mono Lake P. O., in Homer Mining District; elevation 9500 to 12,500 ft.; owner and manager, Thomas Hanna, Martinez, Calif.

The mine was discovered in 1879 and operated continuously from that date until 1898. Since then it was operated at intervals until 1914. The total production is reported to have been $2,000,000. In 1937, a 140-ton flotation plant was installed on the property to treat tailings from former 20-stamp mill, the estimated amount of tailings being 60,000 tons, with an average value of $4.23 per ton in gold.

The country rock is slate and granite. Two veins, known as the May Lundy and West veins occur in granite. These veins strike northwesterly and dip 45° to 50° southwesterly and are from 2 ft. to 4 ft. wide. Vein quartz carries free gold and some pyrite. The lode is developed by 4 tunnels. The main working tunnel is a crosscut 4000 ft. long and intersects the May Lundy vein 1500 ft. below outcrop, with a drift on the vein to the north 1800 ft.

Mill: The power plant to operate mill is located on Mill Creek, 2 miles south of the mine. The hydroelectric plant consists of Pelton wheel which drives 250 K. V. A. General Electric generator, developing 180 h.p., with 100 h.p. at mill. Power line from power plant to mill is 10,200 ft. in length. Tailings from pond are pumped by 3-in. Byron Jackson pump 15-h.p. motor to 8-ft. Allen cone, overflow to 30-ft. Dorr thickener. From Dorr thickener pulp is delivered to 2 storage tanks in mill; from these tanks through 3-in. pipe line to head of duplex Dorr classifier in closed circuit with 5 ft. by 4½ ft. Allis-Chalmers ball mill (which also is fed by sands from Allen cone), driven by 50-h.p. Allis-Chalmers motor. The pulp is ground to minus 65 mesh which goes to 6-cell Kraut flotation machines; concentrates from these to one Kraut cleaner cell; concentrates from cleaner cell to sump; from sump, concentrates pumped to Amico filter. The concentrates produced are reported to carry 4 oz. in gold per ton. Tailings are reported to carry $1.05 in gold. Eight men are employed.

Bibl.: State Mineralogist's Reports VIII, p. 371; XII, p. 180; XIII, pp. 228-229; XV, pp. 170-171; XXIII, pp. 385-386.

Mono Lake and Spring Gulch Group of Claims is in Sec. 25, T. 3 N., R. 25 E., in Spring Gulch, 9 miles north of Mono Lake P. O.; owner, E. Mason, 476 Santa Anita St., Burbank, Calif.

A quartz vein 12 in. to 18 in. wide occurs here in the granite. Its strike is E.-W., dip 45° S. The quartz is said to carry from $10 to $100 in gold. Development consists of an opencut, a 30-ft. tunnel and a 15-ft. shaft. Idle.

Monte Christo Mine, consisting of 3 patented claims, Montecello, Monte Christo and Headlight, lies between the Mammoth and Mammoth Consolidated properties, on the west slope of the Sierra Nevada, just south of Lake Mary, in the Mammoth Lakes Mining District; elevation 9200 ft.; owners, R. L. Warren and C. R. Collins, Box 134, Whittier, Calif.

The country rock is quartzite and diorite. Former operators had driven a crosscut tunnel N. 45° E. some 1400 ft. expecting to intersect the Mammoth vein. Present owners have continued the tunnel to 1540 ft. At 1500 ft. from the portal, a branching raise has been put up 150 ft. This raise is inclined to the northwest. It is reported that the raise has encountered ore 10 ft. wide at its top.

Four men are working building bin and bunk house. It is intended to ship ore to the mill at Benton. A compressor will be brought in next spring.

Bibl.: State Mineralogist's Reports VIII, pp. 373-375; XXIII, pp. 384-385.

New Bodie (Syndicate) Mine is in the Bodie District, adjoining the Standard on the north. This property, consisting of the Whitney, Tioga, Osceola and Eva claims, is owned by Warren Loose, Bodie, Calif.

In the years 1934-1937, the owner was engaged in milling the Tioga dump. The dump material was handled by dragline to a trommel with 1-in. screen. Minus 1-in. material hauled by truck to mill in bottom of the canyon. From a bin the ore was fed by Challenge feeder to 5-ft. Chilean mill, thence to plates. Water was obtained through 3000 ft. of 3-in. pipe from the Syndicate Springs. Power was supplied by 85-h.p. oil engine.

It was stated that about two-thirds of the dump material went to the mill and averaged $12 per ton. Idle.

Bibl.: State Mineralogist's Reports VIII, p. 387; XII, p. 184; XIII, p. 232; XV, pp. 159-160; Rept. of Director of U. S. Mint, 1883, p. 175.

New York Mine adjoins the Serita Mine in the Masonic Mining District. Idle.

Bibl.: State Mineralogist's Report XV, p. 164.

Paragon Group of 5 claims is in the Indian Mining District, 8 miles south of Benton; elevation 7750 ft.; last known owners, Geo. L. Wallace and S. N. Looney, Benton, Calif.

The quartz vein which occurs between granite and rhyolite has a very prominent outcrop, some 30 ft. in width. A sample taken across this 30 ft. is reported to carry 0.35 oz. of gold.

Development consists of two tunnels. The upper tunnel was driven south 50 ft., some 50 ft. below the outcrop. About 25 ft. below this tunnel, a crosscut was driven in the granite foot wall 100 ft. to the vein. The property was formerly owned by Pat Ready and is reported to have had some production. Idle.

Parrett Mine. It comprises 14 claims situated in the Sierra Nevada Mountains, on the ridge south of Mill Creek, in Sec. 19, T. 2 N., R. 25 E., M. D. M., in Homer Mining District, one mile west of Lundy and 8 miles northwest of Mono Lake P.O.; elevation 9000 ft.; owner, Hillis Parrett, Mono Lake, Calif.; under lease and bond to A. A. Chastek and W. J. Chastek, of Los Angeles.

The country rock is granite, slate and andesite porphyry. There are two vein systems on the property, one strikes N. 15° W. and dips 52° W. The other strikes N. 70° W. and dips 20° SW. These veins occur in slate. West of the Bonanza workings, there is a large outcrop of andesite porphyry reported to carry values in gold. The strike of this porphyry lode, known as Niomi vein, is N. 30° W., dip 46° W. and has a width of several hundred feet.

The principal development work has been confined to the Bonanza and Don Alvadore No. 2 claims. On the Bonanza vein, at an elevation of 10,000 ft., a tunnel has been driven S. 70° E. 100 ft. on quartz vein in slate. Vein width is 12 in. to 18 in. At 25 ft. from the portal, vein was stoped for a length of 70 ft., 20 ft. above tunnel level; also underhand stope 20 ft. below level. At 25 ft. from the portal, there is a winze 40 ft. deep, at the bottom of which there is a drift west 25 ft. and east 15 ft. Vein quartz is mineralized with free gold, associated with pyrite and pyrrhotite. Ore milled from these workings is said to have averaged $100 per ton in gold.

The present development has been on Don Alvadore No. 2 Claim located 1500 ft. south of the camp and on ridge south of Mill Creek. At an elevation of 9000 ft. a tunnel has been driven south 15° east, 450 ft. on a quartz vein in slate. The vein has a width of 2 ft. and dips 52° west. The vein quartz is mineralized with pyrite, galena and pyrrhotite. At 90 ft. from the portal is a small stope 12 ft. above level.

Mine equipment consists of 120-cu. ft. Gardener-Denver compressor driven by 72-h.p. Scott gas engine. There is a 2-stamp mill at camp. Four men are employed.

Bibl.: State Mineralogist's Reports XII, p. 182; XIII, p. 230; XV, p. 172; XXIII, p. 386.

Pittsburg-Liberty Mine, comprising 4 patented claims known as the Pittsburg, Pittsburg No. 2, Liberty and Liberty No. 2, is in Secs. 15 and 16, T. 6 N., R. 26 E., M. D. M., in the Masonic Mining District, about 12 miles northeast of Bridgeport; elevation 8000 ft.; owner, E. Grace Parker et al, of Bridgeport, Calif.

Five parallel veins occur in the schist, strike N. 25° W., dip 70° to 90° E. Development consists of a shaft 172 ft. deep and two tunnels cutting the veins at a depth of 271 ft. and 413 ft. Total underground workings aggregate 6000 ft. It is reported to have produced $700,000.

The property was equipped with a 60-ton cyanide plant, power being furnished by 100-h.p. gas engine. Recently the property has been sampled by E. A. Montgomery. Idle.

Bibl.: State Mineralogist's Report XV, pp. 161-162.

Price Group of 8 claims adjoining the Parrett Mine on the east, is about a mile west of Lundy and 8 miles northwest of Mono Lake P. O.; elevation about 9000 ft.; owner Ev Jastad, Mono Lake P. O., Calif.

It is reported that the vein 10 ft. in width has been exposed by opencuts for a length of 600 ft. Values are reported to be $12 to $15 per ton. Idle at present.

Rancheria Placer, consisting of 160 acres, is 6 miles west of Mono Lake; elevation 7300 ft.; owner, W. R. Hunnewell, Bridgeport, Calif.

A large cut 1700 ft. long, 200 ft. wide and 75 ft. deep has been made on the property. The gravel from this cut washed with water from Virginia Creek is said to have yielded over $80,000. Idle.

Bibl.: State Mineralogist's Report XXIII, p. 387.

Red Rock Mine is in Sec. 20 T. 6 N., R. 26 E., M. D. M., in the Masonic Mining District, 12 miles northeast of Bridgeport; owners, J. D. Martin, Robert Batcher and Verne Smith, Santa Rosa, Calif.

Development consists of a 50-ft. shaft and several short tunnels. Idle.

Bibl.: State Mineralogist's Report XV, p. 165.

Roscklip Mining Co. (see Standard Mine).

Rough and Ready Mine is in the Masonic District, 12 miles northeast of Bridgeport. It is developed by two tunnels 300 and 350 ft. in length. Idle.

Bibl.: State Mineralogist's Report XV, p. 164.

Serita Mine is in Sec. 21, T. 6 N., R. 26 E., M. D. M., 12 miles northeast of Bridgeport in the Masonic Mining District; elevation 8000 ft.; owner, S. B. Mosher, 811 West 7th St., Los Angeles.

This old property was reopened in 1929. The 50-ton cyanide plant was rehabilitated and put into operation for a short time and then shut down. Idle.

Bibl.: State Mineralogist's Reports XV, p. 162; XXIII, p. 388.

Sacramento Mine, comprising 6 claims, is in Sec. 2, T. 5 S., R. 32 E., on the west slope of the White Mountains, 11 miles north of Laws and 3 miles northeast of Chalfant Siding on the Southern Pacific Railroad; elevation 6000 ft.; owner, Joseph Smith, Laws, Calif.

The quartz vein in granite strikes N. 30° E., dips 30° NW. It is from 18 in. to 4 ft. wide. Development consists of a 300-ft. shaft on the vein from which workings considerable ore was stoped prior to 1890. Below this shaft four tunnels have been driven into the hill. The upper, No. 1 tunnel, was driven 300 ft. on the vein. Some stoping was done above this tunnel. No. 2 tunnel was driven 550 ft. on the vein, then crosscut east 900 ft. Vein is 2 ft. to 4 ft. wide in these workings. No. 3 tunnel north 30° east 450 ft. on the vein which is 4 ft. wide here. At face of tunnel is a winze 50 ft. deep with 100-ft. drift north which ends at a fault. Strike of fault is E.-W. No. 4 tunnel is a crosscut east 150 ft., with a raise to No. 3 tunnel. The ore in these workings is said to carry \$15 to \$16 per ton in gold, largely free. Idle.

Bibl.: State Mineralogist's Reports XII, p. 183; XIII, p. 230; XXIII, p. 388.

Sierra Group of 6 claims is in Mammoth Lakes Mining District, in Secs. 9, 10, 15 and 16, T. 4 S., R. 27 E., 2 miles west of Mammoth Lakes P.O. It adjoins the Mammoth Mine on the west and northwest; elevation 9000 ft.; owner, Dr. R. D. Owen, Mammoth Lakes, Calif.

On Sierra No. 3 Claim a tunnel has been driven south 135 ft. on a quartz-porphyry lead which is 15 ft. to 20 ft. wide and carries pyrite and arsenopyrite. A 4-ft. quartz vein is said to carry \$4 in gold. On Sierra No. 4 Claim there is a vertical shaft 80 ft. deep. South of this shaft an opencut exposes 4 ft. of barite. On No. 6 Claim a crosscut

driven north 50° east 400 ft. cuts the vein at 300 ft. from the portal; drift 50 ft. northeast and 50 ft. southwest.

Idle except for assessment work.

Sierra Vista Mine, comprising 25 claims, is in the Chidago Mining District, in T. 3 S., R. 31 E., M. D. M., on the west slope of the Benton Mountains, 11 miles southwest of Benton; elevation 7300 ft.; owner, Jonas P. Jones, Long Beach, Calif.

The country rock is rhyolite and metamorphosed limestone, into which there have been intrusions of diorite. There are three parallel veins on the property; strike N. 10° W. to N. 45° W., with 40° SW. dip. These vary in width from 2 ft. to 4 ft. Vein filling is quartz-porphyry, with numerous streaks of iron oxide through it. The ore is said to carry about one-half ounce of gold per ton.

Practically all of the development work has been done on the Sierra Vista or West vein. This vein has a crystalline limestone hanging and a rhyolite-porphyry footwall. Its strike is N. 10° W., with a westerly dip of 40°. The width is from 2 ft. to 4 ft. It has been opened by three tunnels. The lower or main tunnel was driven as a crosscut east 500 ft. At about 300 ft. from the portal, it encountered the vein, on which drifts were driven north 210 ft. and south 225 ft. At 195 ft. south from the crosscut, a winze was sunk to a depth of 20 ft. At 40 ft. south of the crosscut an ore shoot 125 ft. long by 2 ft. wide was encountered. A little stoping was done here. Another shoot occurs 70 ft. north of the crosscut with a reported length of 140 ft., averaging 2 ft. wide. Fifty feet above this tunnel is a crosscut east 100 ft. to the vein, with a drift north on the vein 100 ft. The upper tunnel is 50 ft. above the middle tunnel. It was driven east 60 ft. to the vein with drifts north and south aggregating 100 ft. At an elevation of 7600 ft., the Pink Monster vein occurs in the rhyolite. It has a NW.-SE. strike and is about 8 ft. in width. A 200-ft. tunnel has been driven on this vein.

In 1935 the following mill was erected on the property: Coarse ore bin to 6-in. by 14-in. jaw crusher; elevator to crushed ore bin; belt feeder to 5-ft. by 4-ft. ball mill to Simplex Dorr type classifier to 4 Groch flotation machines and one concentrating table. Power is furnished by 75-h.p., type Y, Fairbanks-Morse oil engine.

In 1938 the property was under lease to E. H. Barmore, of Los Angeles. Idle.

Bibl.: State Mineralogist's Report XXIII, pp. 388-389.

Simpson Mine (Log Cabin & Sunrise Group of Mines or Mutual). The property comprises 17 claims located in Sec. 1, T. 1 N., R. 25 E., M. D. M., on the east slope of the Sierra Nevada Mountains and 2½ miles west of Mono Lake (7 miles by road); elevation 9500 ft.; owners, *Log Cabin Mines Co.*, c/o F. A. Garbutt, 411 West 7th St., Los Angeles. This company acquired the property from the *Mutual Gold Mining Co.,* 401 Fernwell Bldg., Spokane, Wash. The Mutual Gold Mining Co. had been operating intermittently since 1933.

There are two groups of claims known as Log Cabin and Sunrise. On the Log Cabin group, there are five parallel veins that strike NW. Several of these veins dip 70° E. The others dip 35° W. The widths

of the veins vary from 2 ft. to 16 ft. The country rock is a metamorphic slate and quartzite. The ore is oxidized gold quartz, showing free gold and hematite. Values vary from $10 to $25 per ton in gold.

On the Sunrise group of claims, which is located on the east slope of the ridge overlooking Mono Lake, there are two systems of veins. One strikes E. and W.; the other N. and S.; dip 45° W. The country rock is limestone, with thick beds of shale and slate.

Development consists of four tunnels from 50 ft. to 600 ft. in length on the north-south vein system. The hanging wall is slate, with limestone footwall; veins vary in width from 2 ft. to 4 ft. The ore from these workings is stated to carry from 20% to 40% lead with gold and silver values. The present company has confined its development work to the Log Cabin group of claims. The vein strikes N. 30° W., dips 34° W., between slate walls; width 4 ft. to 16 ft.

There is a 2-compartment vertical shaft 280 ft. deep, with levels at 75, 125, 200 and 280 ft., known as first, second, third and fourth

Photo by L. G. Blakemore

100-ton Mill at Simpson Mine

levels. On the first level, a crosscut 190 ft. east intersects the vein. There is a drift (adit) 460 ft. north and 520 ft. south on the vein. On the second level there is a crosscut 70 ft east to vein, with drifts 250 ft. north and 580 ft. south; on the third level, crosscut 20 ft. west to vein, drift 580 ft. south; on the fourth level, crosscut 70 ft. west to vein, drift 650 ft. south. On this level, there is also an adit for drainage driven south from the gulch some 1200 ft. connecting with north drift from the shaft. In addition, there are six raises completed between levels and three more are now being put through (Sept., 1939). Since the ground is heavy and the vein is somewhat shattered, it is proposed to mine fifty per cent of the vein by widening these raises and square setting. When fifty per cent has been removed, the stopes will be filled and the balance removed in the same manner. It is said that all of the drifts are in ore. This would indicate that the shoot has been opened for over 800 ft. in length and the ends have not yet been reached.

Mine equipment consists of 75-h.p. electric hoist and Ingersoll-Rand, Imperial Type 10, air compressor.

A 10-stamp amalgamation plant treating something under 50 tons per day is in operation. A new mill is practically complete and will soon be in operation. It consists of the following: Mine cars are trammed to the top of 300-ton steel, cylindrical bin, with conical bottom, grizzly to 18-in. by 24-in. jaw crusher, 16-in. inclined conveyor to 300-ton crushed ore bin (same as coarse ore bin), Hardinge constant weight feeder, with electric ear control, to 65 Marcy ball mill, to Clark-Todd amalgamator to Dorr Multizone classifier, with automatic pulp density control, all steel construction. Capacity is expected to be about 100 tons per day.

Power is supplied by Southern Sierras Power Co. Forty men are employed, 8 underground, 32 on surface and construction.

Bibl.: State Mineralogist's Reports XV, p. 171; XXIII, pp. 383-384.

Sour Dough Mine, comprising 6 claims, adjoins the Gold Crown Mine on the south, in the Chidago Mining District about 11 miles southwest of Benton; elevation about 7600 ft.; owner, Wm. Ray, Laws, Calif.; leased to Joseph Gilleland, Los Angeles.

A quartz vein, strike N.-S., dip 55° to 60° W., occurs between a granitic foot and a schist hanging wall. It varies in width up to 20 ft. Vein filling is quartz and iron-stained, decomposed country rock.

Development consists of a shaft sunk on the vein 65 ft., with a drift 65 ft. north at the bottom. The full width of the vein is not exposed by the drift. Some 400 ft. north of this shaft there is an open cut 25 ft. long which exposes 2 ft. of quartz and 5 to 7 ft. of additional vein matter. Data on average values was not available. Idle.

Southern Belle Mine, consisting of 9 claims, is in T. 5 S., R. 34 E., partially in Mono County, the south end of the property being in Inyo County. It is on the west slope of the White Mountains, about 5½ miles north of Laws; elevation about 5000 ft.; owner, E. R. Rudolph (estate), Laws, Calif. From about 1931 to 1937, the property was under lease to *P & L Syndicate,* Commander M. R. Pierce, U. S. Navy, retired and E. R. Luderer, Pasadena, Calif.

This is an old property reported to have produced $250,000 prior to 1904. It was working at the time of the San Francisco fire (1906) when all the records were destroyed. Supposedly shut down about 1907; relocated by Rudolph in 1910.

Rock formations of this area include slate, shale and interbedded limestones which have been upturned, eroded and intruded by granitic rocks at points several miles south of this property. No igneous rocks have been found on this mineralized area. The property is divided into three parts, the Southern Belle, New Year and Bullion mines.

Southern Belle: Six veins have been exposed on this property. Three of these which have been the main producers are east-west veins, dipping 30° to 45° N. The other three are steeply dipping north-south fractures which cut the east-west veins. Some stoping has been done on the north-south veins. The Southern Belle vein is estimated to average 7 ft. in width. Its strike is E.-W.; dips about 40°-45° N. It has been developed by a tunnel driven east 350 ft. The vein has been

worked to about 400 ft. through a shaft. Both walls are schist. There is a total of 3050 ft. of workings here consisting of 1900 ft. of horizontal drifts, 862 ft. of winzes and 288 ft. of raises. It is said that 1150 ft. of this work was in ore. The average value of ore extracted is said to have been well over $30 per ton. Two other east-west veins, Rudolph and Pierce, have had some work done on them, yielding some $40 ore from a narrow streak on the hanging wall. The schist underlying these east-west veins is said to carry gold values but the amount has not been determined.

New Year Mine lies about 1500 ft. south of the Southern Belle. It is in Inyo County. This property and the Bullion were equipped with machinery about 1903 and operated until 1906; relocated by Rudolph in 1923.

The vein strikes N. 30° W.; dips about 70° NE., up to 25 ft. in width. There is also a strong vein N. 35° W.; dip 50°-60° W., 3 ft. to 6 ft. wide. Vein filling is quartz. Other minerals are known to be oxidized to a depth of 300 ft. The New Year vein has been developed by three tunnels. The upper tunnel, at an elevation of 5150 ft., opens a 5-ft. vein for 300 ft. There is a 50-ft. winze, some stoping above the drift. A crosscut connects with 110-ft. vertical shaft which was used as an ore pass from the Bullion Mine.

Main development is in middle tunnel at an elevation of 5040 ft. An inclined shaft was sunk 260 ft. This was sunk on an ore chimney which on the 200-ft. level was reported to be 25 ft. wide by 100 ft. long, carrying about $6 per ton. Lower tunnel elevation 5000 ft., 150 ft. northeast through altered schist; cut a vein at 75 ft., strike N. 32° W., dip 75° NE.; 3 ft. to 5 ft. wide. Drifted 60 ft. on vein showing 8 in. to 12 in. of good-looking quartz.

Bullion Mine is 1250 ft. east of the New Year. It is developed by 375-ft. inclined shaft, with levels at 45, 135, 165, 235, 330 and 375 ft. The ore body was oval shaped, up to 20 ft. wide. It was faulted on the 330-ft. and not found on the 375-ft. level. At the 235-ft. level values had dropped to $4 ($20 gold). Some narrow, higher grade ore was found in the lower levels.

Just south of the New Year workings there is a schist zone about 110 ft. wide, traceable for 1000 ft. which contains many quartz stringers. Various samples which have been taken indicate values of about $3.90 across 52 ft. and $1.70 across another 40 ft.

There is a small mill on the property, consisting of the following: 6 by 8 jaw crusher; three 1250-lb. stamps, plates and one concentrating table. Power is supplied by a 20-h.p. gas engine. Idle.

Bibl.: State Mineralogist's Reports XII, p. 183; XIII, p. 231.

Southern Consolidated Mine, at Bodie, comprises the old Noonday, Red Cloud, Addenda, Oro and Defiance (in all 12 claims of which 9 are patented); elevation 8500 ft.; owner, Southern Consolidated Mining Co.

This old property which has long been idle, was developed to a depth of 900 ft. on parallel veins in andesite. It is said that the underground workings aggregate about 5 miles. The combined production amounted to $1.048,372, of which the Noonday produced $1.023,289. At present the Roseklip Mining Co. is taking water for its mill from the Red Cloud Shaft.

Bibl.: State Mineralogist's Reports VIII, p. 396; XII, p. 182; XIII, p. 230; XV, pp. 158-159.

Standard Mine, comprising 20 patented and 14 unpatented claims, is at Bodie; elevation 8400 ft.; owner, Standard Consolidated Mining Co., J. S. Cain, Bodie, Calif.; leased to *Roseklip Mines Co.*, John Rosekrans, president, Woodside, Calif.; H. W. Klipstein, vice president, Mills Bldg., San Francisco, Calif.

Old Standard Mill at Bodie—still intact

Mill on Standard and Red Cloud at Bodie (has been removed)—
Treadwell-Yukon Co.

This property was the largest producer of the district. From 1877 to 1914, the production amounted to $18,202,856 of which $5,264,407 was paid in dividends. There is no record of its production from 1860 to 1877 nor are complete figures available on the more recent operations.

In 1929 the *Treadwell-Yukon Company, Ltd.*, of San Francisco, took a lease on the property and erected a 200-ton amalgamation and flotation plant for the treatment of ores on the dump. This plant operated during 1931 and 1932 and recovered over $200,000 in gold and silver from the dumps. This operation was given up in the latter part of 1932 and the mill was removed.

The present lessee started operations in 1936. A 250-ton cyanide plant was erected for treatment of the dumps on the property. Dumps are loaded into trucks by two power shovels, and hauled to hopper,

Present Plant of Roseklip Mines Co.,
Treating Dumps at Bodie

from hopper to 36-in. jaw crusher to Hardinge scrubber; the scrubber fines to Hardinge hydro-separator, fine product to 2 Kraut flotation cells; scrubber tails to Traylor, type TY crusher to 500-ton crushed ore bin, to 6-ft. by 48-in. Hardinge ball mill, to multi-zone Dorr classifier to duplex Dorr classifier; sands to nine 22 by 10-ft. sand tanks; slimes to five 16-ft. by 16-ft. agitators; Merrill-Crowe precipitation. Machines have individual motor drives. Extraction is 82%. Sixty per cent of value is gold, 40% silver. Twenty-eight men are employed.

Operators are driving a new tunnel to get under the old Standard ore bodies. For description of the mine and its former operations, the reader is referred to the bibliography below.

Bibl.: State Mineralogist's Reports VIII, p. 385; XII, p. 183; XIII, p. 231; XV, pp. 150-158; XXIII, pp. 389-391; Director of U. S. Mint, 1883, pp. 173-175.

Success Mine is situated in the Masonic Mining District, one mile south of the Chemung Mine, 9 miles northeast of Bridgeport; last known owners, John H. Hayes and C. C. Hayes, Bridgeport, Calif.

The vein strikes northeast and dips to the east. The country rock is andesite. The vein is 3 ft. wide and is said to carry $11 per ton in gold. Idle.

Bibl.: State Mineralogist's Report XVIII, p. 416.

Tioga Mine is an old property near the crest of the Sierra Nevada, at the head of Leevining Creek, 12 miles west of Mono Lake; elevation 10600 to 11000 ft.; owner, Antionette S. Swift. In 1934 the property was leased to Tioga Mining Co., of New York, Hulbert A. Yerkes, president; W. R. Palmer, superintendent. The property was originally located in 1878 and worked until 1884 by the *Great Sierra Mining Co.*

The country rocks are metamorphosed sediments highly tilted and folded. The general strike of the veins is NW.-SE., with a steep dip to the SW. They vary in width from 6 ft. to 40 ft. They are filled with quartz carrying argentiferous and auriferous mixtures of pyrite, chalcopyrite and sphalerite, with subordinate amounts of bornite and galena.

The principal work on the property was a crosscut driven south 30° west about 1800 ft., with an estimated 200 ft. to go to the Sheepherder lode. In 1934, some 20 men were employed driving this tunnel. Idle.

Bibl.: State Mineralogist's Report VIII, pp. 371-372.

Twenty Grand Mine, comprising 10 claims, lies between Coldwater and Piute canyons on the west slope of the White Mountains, about 10 miles northeast of Laws; elevation 6500 ft.; owners, Joseph Smith and Wm. Ray, Laws, Calif.

Country rock is monzonite, with some quartzite and dolomitic lime stone. A series of parallel, flat dipping veins occurs in these rocks. They vary from 2 ft. to 6 ft. in width. There is also a massive northeast-southwest vein up to 20 ft. wide which dips from 30° to 40° southeast. The veins are filled with quartz which has been brecciated and recemented. There is considerable iron oxide in the quartz and the gold is associated with this mineral, as well as galena and lead carbonates.

Development: On the south side of the hill a tunnel has been driven north 600 ft. in the hanging wall of a vein which strikes N. 20° W. and dips 30° W. The outcrop of this quartz is 20 ft. wide. It occurs in the quartz monzonite. On Twenty Grand No. 6 Claim, there is a tunnel driven east 120 ft. on a vein 2 ft. wide; strike N.-S., practically horizontal. The vein which occurs in quartzite and quartz diorite is highly oxidized. There is another 40-ft. tunnel on this claim. On Claim No. 4 a 60-ft. incline shaft has been sunk on a quartz vein whose outcrop is from 15 ft. to 20 ft. wide. The main workings are on the north face of the ridge. Here a tunnel has been driven south 40 ft. where a 200-ft. winze has been sunk on a 15° inclination; also, on tunnel level drift west 200 ft. The vein 12 in. wide is mineralized with galena, lead carbonates and iron oxide. Its strike is NE.-SW., dip 15° SE. It is reported that five cars of $60 ore were shipped from these

workings. About 200 ft. east of this tunnel, a tunnel has been driven south 50° east 300 ft. Dip of the vein is 40° SW.; 8 ft. to 12 ft. wide, all quartz. This tunnel is approximately 300 ft. below the inclined winze.

On Claim No. 1, the Gardner crosscut was driven about 300 ft. northwest toward the incline. This crosscut is about 250 ft. below the crest of the hill and is just west of a quartz vein 10 ft. to 12 ft. wide; strike NE.-SW., dip SW. Above this tunnel on Claim No. 2, crosscut south 25 ft. to a vein; drift 125 ft. northeast on the quartz vein which is 5 ft. to 7 ft. wide. It is said to average $8 to $10 per ton in gold. The outcrop of this massive quartz vein is very prominent. Claim No. 1 is under lease to Jess Dunlap, Laws, Calif.

The property was first worked in 1870 at which time the gold was extracted by arrastras, located in Piute Canyon.

Virginia and Dog Creek Placers. Gold is known to exist in the gravels of these creeks at their confluence and a distance of three miles or more above.

In 1931 a shovel and screening plant was installed on property owned by A. J. Warrington (deceased). This property consisted of 280 acres, extending along Virginia Creek for a distance of 18,000 ft.

The gravel is about 10 ft. deep and 200 ft. wide. Values reportedly range from 5¢ to 50¢ per yard. The real pay gravel is approximately 4 ft. deep on a decomposed granite bed rock and, in places, is said to carry from 50¢ to $1 per yard. Idle.

LEAD, SILVER AND ZINC

The earliest mining in Mono County was that of the silver ores in Blind Spring Hill, in the Benton District in the southeastern portion of the county. The discovery of these ores was made in 1862 and for the next twenty-seven years (to 1890) there was considerable activity in this area, resulting in the production of $4,215,869. Other productive districts in this area were known as Indian, Clover Patch and Chidago, about 8 to 12 miles southwest of Benton. The most productive mines of these districts were the Comanche, Diana-Kerrick and Cornucopia, having a combined production of $2,200,000. The other important silver-producing district of the county is known as the Patterson. It is on the slope of the Sweetwater Mountains and on the California-Nevada line. The two most productive mines were the Kentuck and the Silverado.

The ores of Blind Springs Hill are complex associations of antimonial minerals of copper, lead and silver, with small amounts of gold. These minerals are pyrite, chalcopyrite, bornite, tetrahedrite, stromeyerite, sphalerite, galena, argentite, pyrargyrite, stephanite, cerargyrite, native silver, 'partzite,' anglesite and cerussite. The ore minerals found in the veins of the Patterson District are argentite, cerargyrite, pyrite and small amounts of native gold associated with magnetite and other iron oxides.

Silver also occurs associated with the gold ores of the Bodie and Mammoth districts in appreciable amounts. Deposits of lead-zinc ores occur in the narrow belts of crystalline limestone on the eastern

slope of the Sierra, the principal occurrences being in the vicinity of Gull, June and Virginia lakes.

The suspension of operations at the Silverado Mine in 1938 leaves the Standard at Bodie the only noteworthy silver producer in the county.

MINES

Banner Mine (Old Glory), comprising 19 claims, is in the Chidago District, 12 miles southwest of Benton; elevation 8000 ft.; last known owner, *Universal Ore Milling & Mining Co.*, Reno, Nev.

The Banner lode, with granite walls, strikes N. 40° W. and dips 15° SW. It was worked through several small shafts to a depth of about 150 ft. on the dip.

It was operated from 1870 to 1884, the ore being treated by a small mill at Banner Springs. Idle.

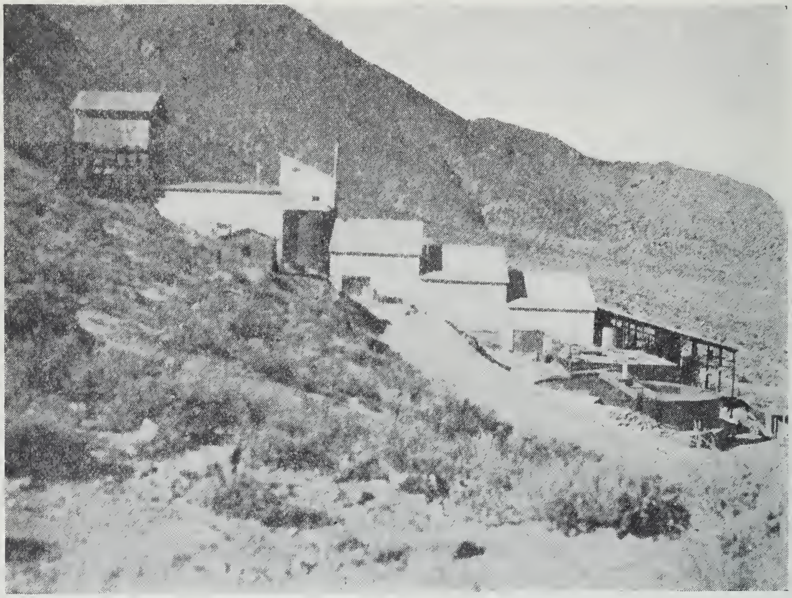
Bibl.: State Mineralogist's Reports VIII, pp. 378-379; XXIII, p. 393.

Comanche Mine (silver-copper). The property comprises the Comanche and Diana-Kerrick group of mines, situated in Sec. 7, 13, 18, 19 and 24, T. 2 S., R. 31 and 32 E., M. D. M., in the Blind Spring Hill Mining District, 2 miles south of Benton, a station on the Carson & California Railroad; elevation 5400 ft. to 6800 ft. The mining property consists of 36 patented mining claims and 20 unpatented claims, containing about 1120 acres. The company also owns 240 acres of patented land on the east side of Blind Spring Hill along the line of the Southern Pacific Railroad. The present camp and townsite are located on this land; owner, Comanche Mining & Reduction Co., George W. Adams, president, 725 Title Insurance Bldg., Los Angeles; mines under lease to F. L. Main, 2875 Hollyridge Dr., Hollywood, Calif., with contract to furnish ore to Mineral Reduction Co., C. W. Jones, president, 337 West Ave. 26, Los Angeles.

The Comanche lode was discovered in 1862 and actively worked from that date until 1879, the Comanche being credited with a production of $1,000,000, the Diana and Kerrick mines with $900,000 and the Cornucopia Group with $300,000. More than one-half of the output of Blind Spring Hill District was produced by the mines now owned by the Comanche Mining & Reduction Co. This company acquired the property in 1921 from which date a large amount of development work was done on the Comanche and Kerrick mines and from January, 1929, to January, 1930, two hundred and fifty-four tons of high grade ore was shipped from the Kerrick Mine, with a gross production of $30,000. Due to low price of silver, operations were suspended in February, 1930.

Blind Spring Hill, in which the Comanche, Diana, Kerrick, Cornucopia and Boraska mines are located, is about six miles from north to south and from two to three miles east and west. The mountain mass is granitic and is traversed by a system of fault fissures which strike north and south, roughly parallel. The veins have a strike of N. 10° W. to N. 20° W. The dips of the different veins vary from 40° to 45° E., the only exception being the Comanche vein which dips 82°

E. The veins are cut by a series of parallel fault fissures that strike E. and W. that cause normal faulting. The veins vary in width from 2 ft. to 7 ft. The ore bodies of these lodes occur as irregular lenses which have a general trend to the south and vary in length from 20 ft. to 100 ft. and evidently form more or less continuous shoots of ore of greater length. The ore occurs as a complex association of antimonial ores of copper, lead and silver, with small amounts of gold in irregular lenses in quartz veins occupying fault fissures in granodiorite. The irregular lenses of ore that occur in the different veins comprise a streak of high grade antimonial silver-copper ore that varies in width from 3 in. to 2 ft., the remaining vein material being a silicified porphyry.



100-ton Flotation and Cyanide Plant
Comanche Mine

The general average value of the vein material in these lenses varies from 10 oz. to 30 oz. of silver, with low gold values. Shipments from the high grade streak returned from $100 to $200 per ton.

The Comanche vein has been developed by a crosscut east 1440 ft. intersecting the vein south of the main shaft at a depth of 350 ft. Drifts have been driven north 450 ft. and south 600 ft. There is also a 750-ft. shaft, the workings of which are caved and inaccessible. A winze was sunk from the tunnel to the 750-ft. level. The ore has been stoped to this depth.

The Diana-Kerrick vein has been developed and worked through the Diana shaft to a reported depth of 800 ft. These workings are now caved. The Kerrick shaft, approximately 1500 ft. north of the Diana shaft, was worked to a depth of 650 ft. on 40° inclination, with a reported production of $400,000. Later this shaft was sunk to 1400 ft. A commercial grade of ore was exposed from the 750 to 1280-ft

level. Lateral development in the lower levels of this shaft is as follows:

850-ft. level	—north 180 ft.;	south 420 ft.
1000-ft. level	—north 240 ft.;	south 650 ft.
1200-ft. level		south 200 ft.
1280-ft level		south 200 ft.

There are also 5 raises with a total length of 896 ft.

All of the above development is on the west slope of Blind Springs Hill. On the east slope, at an elevation of 5400 ft., the Ross tunnel was driven west 4320 ft. At 4116 ft. it cut the Kerrick vein on which drifts 170 ft. south and 230 ft. north were driven. At 170 ft. north of the crosscut, a raise was driven 360 ft. connecting with the Kerrick shaft at its 1400-ft. level.

The present operator has been shipping the ore from Kerrick Mine to a mill built near the portal of the Ross tunnel. From 200-ton coarse ore bin to belt feeder to 10-in. by 20-in. Blake crusher, to 8-in. by 15-in. Wheeling crusher to 36-in. by 16-in. rolls, to 200-ton crushed ore bin to 5-ft. by 7-ft. ball mill in closed circuit with Dorr multizone classifier to conditioner to pneumatic floatation cell (deep type) 12 ft. long by 10 ft. deep and 4 Fagergren cells, to two 3-ft. by 4-ft. Oliver filters. Capacity is 100 tons per day.

Water is obtained from a 100-ft. well just below the mill. Power is supplied by 200-h.p. diesel engine, direct connected to 175 kilowatt generator. Machines have individual motor drives.

Forty men working on construction. Twelve men will be required for operation and 15 men at mine.

Bibl.: State Mineralogist's Report VIII, p. 376; XXIII, pp. 393-395.

Cooney Zinc Mine (lead-zinc), comprising 6 claims, is 5 miles southwest of Virginia Lakes Service Station at Conway Summit and about 14 miles south of Bridgeport; elevation 9400 ft.; owner, Mrs. Bertha Hall, Glacier Lodge, Big Pine, Calif.

The country rock is limestone and quartzite. The outcrop, some three hundred feet in width, contains hornblende, pyroxene, epidote and garnet and occurs in the limestone. It is traceable for several hundred feet. The strike of the outcrop is N. 40° W.

Development consists of three or four opencuts, a shaft approximately 100 ft. deep (inaccessible at time of visit) and a crosscut tunnel driven southwest about 170 ft. In this tunnel, at 30 ft. from the portal, a lead-zinc sulphide ore body 40 ft. wide was encountered. It is reported that samples cut across this 40 ft. averaged 18% zinc, 10% lead with 4 oz. to 6 oz. of silver per ton.

The type of the deposit, a replacement in limestone and the size of the outcrop indicate favorable possibilities for the development of a large body of ore. Idle except for assessment work.

Bibl.: State Mineralogist's Report XXIII, p. 395.

Huebner Group of Mines (lead-silver), comprising 6 claims, is in the Chidago Mining District, in the Benton Mountains, 12 miles southwest of Benton; elevation 6800 ft.; last known owner, Julius Huebner, Bishop, Calif.

Two parallel veins occur in the granite, strike N. 10° E., dip 70° E. Widths vary from 2 ft. to 4 ft. The vein quartz is mineralized with pyrite, marcasite, galena and iron oxide. The principal values are in lead and silver, with $2 to $5 per ton in gold.

The main development has been on the east vein, on which an incline shaft has been sunk 125 ft. Idle.

Independence Mine (silver), comprising 3 claims, is 10 miles southwest of Benton, on the east slope of the Benton Mountains; elevation 5750 ft.; owner, Jos. Main, Benton, Calif.

A massive outcrop of iron-stained quartz occurs in limestone. The vein strikes N. 30° W. and dips 40° E. A crosscut tunnel has been driven east 75 ft. about 50 ft. below the outcrop and a drift run south on the vein a distance of 90 ft. The vein, in this drift, is 4 ft. wide. To the east of this outcrop, a shaft has been sunk on a parallel fissure to a depth of 150 ft. North of these workings, the vein has been exposed by opencuts for several hundred feet. The ore carries values in silver and a small percentage of lead. Idle.

King Group of 6 claims is situated in the Chidago Mining District, in the Benton Mountains, 10 miles southwest of Benton; elevation 7450 ft.; last known owner, John King, Benton, Calif.

A series of parallel veins occur in the granite to the east of a rhyolite dike. The veins strike N. 30° E., dip 50° W. The widths vary from 2 ft. to 4 ft.

The principal development work is on one of the most easterly veins. At an elevation of 7450 ft. an incline shaft has been sunk on the vein to a depth of 100 ft. and the vein has been stoped from the 50-ft. level to the surface, both north and south of the shaft. About 300 ft. south of this shaft and 100 ft. below it, a crosscut tunnel has been driven 200 ft. southwest to the vein, with drifts north and south on the vein. The vein quartz is mineralized with pyrite, marcasite and galena. The principal values in the ore are gold and silver and occasional bunches of pure galena occur in the vein. Idle.

Lyford Mine, comprising 5 claims, is on the east slope of Blind Springs Hill, 4 miles east of Old Benton; elevation 6400 ft.; owner, W. H. Davis estate, of Benton, Calif.

The Lyford vein strikes N. 15° W. and dips 20° to 35° E. Width of vein varies from 12 in. to 3 ft. The formation is granodiorite. The ore body has been developed by a number of tunnels driven at different elevations. The main tunnel is 400 ft. in length, with two other shorter tunnels above, from 100 to 250 ft. in length. The Lyford vein is faulted by a fault which strikes N. 45° W. and dips N. The fault is 50 ft. wide, filled with a breccia having nearly white clay casings, showing slickenside surfaces and striations. The ore in the tunnel ends at the fault. At the same elevation as this tunnel and to the north of it, a crosscut tunnel is driven in the granite 500 ft. This tunnel was evidently driven to cut Diana-Kerrick vein of the Comanche Mine but work was suspended before reaching this vein.

The ore bodies which have been worked occur in irregular lenses or masses on either the hanging or footwall of the vein. The minerals observed in the ore of the Lyford are similar to those of the other mines

on Blind Springs Hill, namely, pyrargyrite, stephanite, magnetite and cerussite. The reported production of the mine is about $200,000. Idle.

Bibl.: State Mineralogist's Report VIII, p. 382.

Pat Reddy Mine (silver), consisting of 6 claims, is on the east slope of Blind Springs Hill, 4 miles south of Benton; elevation 5000 ft.

Lone Star Mine (lead-silver), embracing 7 claims, known as the St. Ives Group, is in the Chidago Mining District, 12 miles southwest of Benton; elevation 7100 ft.; owners, H. A. Van Loon, et al., Bishop, Calif.

The vein strikes N. 15° W. and dips 80° W. in rhyolite. The quartz filling is mineralized with galena and marcasite, carrying silver and gold values. It is from 18 in. to 3 ft. wide.

Development consists of a 2-compartment shaft, vertical to a depth of 125 ft., then sunk on an incline of 80° a distance of 185 ft. Levels have been driven at the 125, 245 and 300 ft. horizons. On the 300-ft. level, 250 ft. of drifts have been driven north and south of the shaft; also, a crosscut east 770 ft. It is reported that there are 15,000 tons of ore developed in these workings which will run $12 in lead, silver and gold. Idle, except for assessment work.

Bibl.: State Mineralogist's Report XXIII, pp. 396-397.

Silverado Mine (silver), comprising 15 claims known as the Silverado and Kentuck groups, is situated in the Patterson Mining District, in Sec. 19, T. 7 N., R. 25 E., M. D. M., 5 miles west of Sweetwater, Nev.; elevation 8600 ft.; owner, *Sierra Consolidated Mines Co.,* c/o John S. Sinai, Box 218, Reno, Nev.

The Silverado vein strikes N. 20° E. and dips 45° W. Its average width is about 4 ft. The footwall is andesite and the hanging is rhyolite porphyry. The vein-filling is quartz and shattered porphyry. The ore minerals in the vein are pyrite, argentite and cerargyrite, associated with magnetite and other iron oxides.

The mine has been developed by four levels. The main haulage level is known as the 600. The 700-ft. level is 100 ft. above the 600 and the 800 is 100 ft. above the 700. A winze has been sunk 200 ft. below the 600. At 100 ft. below the haulage level is the 500-ft. level. The haulage level is a crosscut driven west 900 ft. to the vein, with a drift south 1500 ft. on the vein. The oreshoot worked was from 600 ft. to 800 ft. long, averaging about 4 ft. in width. The ore is said to average about 16 oz. in silver. High grade, lenticular masses were encountered near the footwall from which shipments were made, returning from $200 to $600 per ton.

The Kentuck Mine, said to be on the Silverado vein, is 4480 ft. south of the Silverado workings and 1400 ft. above the 600-ft. level of that mine. It was opened by two adit levels on the vein to a depth of 300 ft. below the outcrop and a winze explored the vein 100 ft. below the lower tunnel. It has not been worked since 1884. It has a reported production of $500,000.

Power was generated on Green Creek, 9 miles south of Bridgeport and transmitted by a thirty-two-mile line. A 2500-ft. aerial tram transported ore to a 100-ton mill which was originally a cyanide plant but was changed to flotation in later years. The flotation plant had a

capacity of approximately 150 tons per day. About 90,000 tons were treated in the flotation plant. Idle, having been shut down in the early part of 1938.

Bibl.: State Mineralogist's Reports VIII, pp. 359-361; XV, pp. 165-166; XXIII, pp. 398-399; Rept. of Director of U. S. Mint, 1883.

Silver Reef Mine (lead-silver). This property, comprising 4 claims, is on the east slope of the Benton Mountains, 11 miles southwest of Benton; elevation 5900 ft.; owner, Joseph Main, Benton, Calif.

Two parallel veins occur in limestone; strike N. 20° W., dip 60° W.; width 12 in. to 4 ft. The limestone belt is approximately one mile in width and in the vicinity of the veins, it has been intruded by diorite. The vein quartz contains argentite, with bromides and chlorides of silver, galena and cerussite.

Development consists of eight shafts on the most easterly vein. These shafts are about 100 ft. apart and vary in depth from 50 to 300 ft. Shipments of ore from the property are reported to carry $60 to $200 per ton in lead and silver. Idle.

Bibl.: State Mineralogist's Report XXIII, p. 399.

Tower Mine, comprising 2 patented claims, is in the Indian Mining District, 8 miles southwest of Benton, on the west slope of the Benton Mountains; elevation 6400 ft.; owner S. D. Otey, Bishop, Calif.

The vein occurs in granite, strike N. 10° E., dip 80° W. It varies in width from 2 ft. to 4 ft. The ore occurs as irregular kidneys of rich argentiferous pyrite in a quartz gangue. Associate minerals are sphalerite, pyrite, galena and antimonial silver minerals.

Development consists of two shafts, one sunk on the vein to a depth of 200 ft. and about 300 ft. west a vertical shaft, sunk in the footwall to a depth of 300 ft. The mine is reported to have produced $150,000. Idle.

Wild Rose Mine (lead-gold-silver). This property, embracing 5 claims, is in Wild Rose Canyon, in the Chidago Mining District, 6 miles southwest of Benton; elevation 7500 ft.; owner, Sam Morris, Bishop, Calif.

The Wild Rose vein occurs in granite. It strikes N. and dips 70° W. Its width is 4 ft. The vein-filling is quartz and the valuable minerals are pyrite, marcasite and galena, carrying gold and silver. The silver minerals in the vein are argentite and pyrargyrite.

Development consists of crosscut east 200 ft. to the vein, with drifts north and south aggregating 500 ft. At 30 ft. north of the crosscut, there is a winze of unknown depth. The ore was stoped to the surface from the tunnel. Reported production is $100,000. Idle.

MOLYBDENUM

While no commercial deposit of molybdenite has yet been developed in the county, it is known to occur in at least three localities. One of these is on the south face of Bloody Mountain, about one mile west of Lake Genevieve, in T. 4 S., R. 28 E. The other is some 8 miles south of Coleville where C. C. Coffman, of Coleville, reported that he had two claims on which there were three or four veins from 4 in.

to 2 ft. wide which carry 2% molybdenite. The ores of the Black Rock Mine carry some molybdenite and it occurs on the adjoining Ameil Group of Claims.

Bibl.: State Mineralogist's Report XXX, pp. 83-86.

QUICKSILVER

Although there has been no production of quicksilver from Mono County, cinnabar is known to occur in several localities, the most notable of which are at Fale's Hot Springs and Casa Diablo. No work to determine the extent or values in these deposits has been done.

TUNGSTEN

Only one tungsten deposit has been developed as yet in the county. It is described below under the caption Black Rock Mine.

Black Rock Tungsten Mill

Ameil Group of 3 claims adjoins the Black Rock Mine on the southeast, in T. 3 S., R. 31 E.; elevation 6500 ft.; owner, Sam Morris, Bishop, Calif.

Scheelite and molybdenite occur in a garnet and epidote gangue along contact of granite and limestone; strike N. 30° E., dip about 55° NW. The outcrop may be traced for about 1000 ft. Width of the deposit has not been determined. An open cut 35 ft. long, 5 ft. wide by 6 ft. deep has exposed some good ore. Idle except for assessment work.

Black Rock Mine, comprising 8 claims, is in Sec. 14 and 23, T. 3 S., R. 31 E., M. D. M., in Black Rock Canyon, 35 miles by road north of

Bishop and $7\frac{1}{2}$ miles south of Benton; elevation 6500 to 7000 ft.; owner, Archie Beauregard, Laws, Calif.; under lease and option to the *Tungsten Corporation of California*, R. P. Johnson, president; W. R. Hees, Jr., secretary, 811 West 7th St., Los Angeles.

The deposit which is of the contact metamorphic type, occurs at or near the contact of crystalline limestone with dacite. Usually the

Upper Deposit Workings—Champion Sillimanite, Inc.

ore is wholly within the limestone but in places dacite forms the hanging wall. Other rocks encountered in the mine workings are slate, tactite and diorite. The strike of the mineralized zone is N. 10° W.; dip varies from 20° to 70° W. Width of the ore is said to vary from 7 ft. to more than 60 ft. Mineralization consists of finely divided

scheelite, disseminated in a gangue which is largely garnet with subordinate amounts of quartz, calcite, pyrite and magnetite.

The deposit is developed by two tunnels; lower tunnel at an elevation of 6820 ft. driven southwest 275 ft. Upper tunnel is driven southwest 300 ft. In the lower tunnel a winze has been sunk 85 ft. At the bottom a crosscut N. 50° W. 25 ft. drift west 61 ft., all reported to be in ore. There are also two glory holes, the larger one above the lower tunnel, is 70 ft. long, 20 ft. wide and 25 ft. deep.

Equipment at the mine consists of 420-cu. ft. portable compressor. At the head of the aerial tram is a 100-ton coarse ore bin; a 2-in. grizzly and 15-in. by 30-in. jaw crusher to 100-ton crushed ore bin to tram.

The aerial tram which is 850 ft. long delivers the ore to 100-ton bin, $\frac{3}{4}$-in. grizzly to gyratory crusher, to elevator to $\frac{5}{16}$-in. vibrating screen; oversize to 4-ft. by 4-ft. ball mill with 10-mesh trommel screen on discharge; oversize to elevator return to vibrating screen; screenings direct to tables; screenings from ball mill screen to elevator to tables. There are three rougher and one cleaner tables; concentrates to oil fired rotary drier to Stolle electro-static separator. A 3-ft. Allen cone and a 20-ft. Dorr thickener are used for water recovery.

A 4-cylinder, 200-h.p. hot-head engine, direct connected to 170 k.v.a. generator supplies power.

Capacity 80 tons per day. It is planned to double this capacity. Thirty-one men are employed.

NONMETALLIC MINERALS

Mono County has a great variety of commercial minerals, the development of which has been retarded in the past by lack of transportation. As new roads are built into the more isolated sections of the county, a considerable increase in production may be expected. Of those minerals known to occur in the county there are deposits of andalusite, barite, clay, mineral water, pumice, salt, soda, silica, travertine and tuff.

ANDALUSITE

Champion Sillimanite, Inc., Dr. J. A. Jeffrey, president; B. A. Jeffrey, secretary, Detroit, Mich.; local office, Mocalno, Calif.

The deposit owned by this company, comprising 10 claims, is the largest of its kind known to exist in the world. It is located in Dry Creek Canyon, on the northwest slope of the White Mountains, 7 miles east of Shealy, a station on the Southern Pacific Railroad; elevations on the deposit range from 7500 ft. to 10,000 ft.

For a detailed description of the deposit, its occurrence, processing of the material, etc., reference should be made to the publications mentioned in the bibliography below.

The zone in which the andalusite occurs is some two miles long by thirty feet wide. The strike is about N. 20° W. and the dip 75° to 80° SE. Both walls are quartzite and the deposit is believed to be a product of contact metamorphism, the quartzite being in contact with granite and granodiorite. Among the minerals associated with the andalusite are pyrite, topaz, muscovite, dumortierite, lazulite, limonite

and rutile, the last named mineral comprising between 2% and 3% of the ore.

To date, work has been almost entirely confined to the upper deposit at an elevation of 10,000 ft. The ore occurred on the east face of a high cliff at or near the surface. In places it has been quarried while in others it has been stoped, leaving a thin shell of waste on the face of the cliff. At one time a tremendous slide occurred here. Investigation showed that only the hanging wall had slipped leaving the ore in place.

Development consists of tunnels driven along the east face of the cliff from which stoping has been done. Some of these stopes are as much as 50 ft. wide, 100 ft. long and 75 ft. or more high. This tunnel was turned west and driven through the ridge as a prospect. When no ore was encountered, it was decided to move the camp and equipment to the lower deposit which is about one mile south at an elevation of some 7500 ft. This work will begin in the early spring.

Many thousand tons were mined, sacked and carried three miles down the steep trail by pack animals from the upper deposit. It was then hauled by truck about five miles to the railroad at Shealy and shipped to the plant in Detroit.

Electric power is supplied by a hydroelectric plant on the company's ranch at the foot of the mountain. The plant has a capacity of about 375-h.p. Electric power is generated at 400 volts and stepped up to 6800 for transmission to the mine. The mine shuts down for the winter. Operations will be resumed in the spring.

Bibl.: State Mineralogist's Reports XX, pp. 149-154; XXII, pp. 400-401; XXVII, pp. 453-455 and pp. 459-464; Journal, Washington Academy of Science, 1917, by Adolph Knopf, of U. S. G. S.; An Andalusite Mass in the pre-Cambrian of the Inyo Range, U. S. Bureau of Mines, I. C. 6255.

BARITE

Several thousand tons of barite have been mined and shipped into Los Angeles, largely from one property in the county. This material was mixed with bentonite and used as oil well mud.

Cliff property, comprising one claim, is on the west slope of the White Mountains in Gunther Canyon, 7 miles northeast of Laws; owner, Mrs. Sally B. Patterson, Los Angeles. It was under lease to N. C. Wilde, Laws, Calif.

Idle except for assessment work.

Gunther Canyon Deposit, comprising 4 claims, is on the west slope of the White Mountains, on the north side of Gunther Canyon, 7 miles northeast of Laws; owners, Otto Sattler and Edward Reynolds, Howe Lumber Co., Ventura, Calif.

The chimney-like deposits occur in the crystalline-metamorphic rocks of this area, in a zone which strikes N. 40° W. and dips about 60° to 70° northeast. The barite, white to gray in color, occurs in widths from 2 ft. to 8 ft. Its specific gravity is said to be 4.25.

Deposit has been developed by a number of short tunnels, on each side of the canyon; a 250-ft. and an 80-ft. shaft, both on the north side

of the canyon. Shipments have aggregated several thousand tons. Outcrop indicates the possibility of developing additional lenses of this material.

CLAY

Casa Diablo Kaolin Deposit, comprising 4 claims, is about one-half mile east of Casa Diablo geyser.

The deposit, which is up to 20 ft. in thickness, outcrops for several hundred feet along the hillside. It is apparently a good grade of material, white in color, and seems to have resulted from the decomposition of rhyolite.

It has been developed by a series of opencuts and short tunnels. Some shipments have been made to the California Kaolin Co., of Los Angeles. Idle.

Kaolin outcrop at Casa Diablo

PUMICE AND VOLCANIC ASH

Extensive deposits of pumice and volcanic ash occur in the volcanic tableland on the west side of Hamil and Benton valleys. The deposits in Mono County extend from Benton, south to the Inyo County line.

California Quarries Pumice Deposit. This deposit, presumably worked out, was on the west side of Hamil Valley, 6 miles north of Laws. It comprised 640 acres which were owned and worked by the California Quarries Co. whose offices were in 1300 Quinby Bldg., Los Angeles.

Many thousand tons of white pumice were taken from a horizontal bed from 12 ft. to 15 ft. thick which was overlain by red tuff from 25 ft. to 75 ft. thick.

The property was equipped with a 50-ton grinding and separating plant which was destroyed by fire.

Bibl.: State Mineralogist's Report XXIII, p. 403.

Blind Spring Hill Pumice Deposits. These deposits are on the east slope of Blind Springs Hill, about 5½ miles south of Benton; elevation 5200 ft.; last known owners, William Ray, Bishop, Calif. and Joe Moletesta, Hawthorne, Nev.

The pumice is white in color, about 20 ft. thick and has been traced by opencuts for about 1000 ft. Idle.

Bibl.: State Mineralogist's Report XXIII, pp. 403-404.

Sacramento Canyon Pumice Deposit, comprising 40 acres, is on the west slope of the White Mountains, north of Sacramento Canyon, 3 miles northeast of Chalfant, a siding on the Southern Pacific Railroad and 11 miles north of Laws; elevation 5300 ft.; owner, Joseph B. Smith, Laws, Calif.

Photo by Walter W. Bradley

Yellow Jacket Canyon Pumice Deposit of J. B. Smith, Laws

The bed of pumice is exposed on the surface for a length of 500 ft. and 200 ft. in width. It is white in color and most of the material is quite fine, the largest being about the size of a walnut. Idle.

Yellow Jacket Canyon Pumice Deposits, comprising 640 acres, are on both sides of Yellow Jacket Canyon, south of Yellow Jacket Spring, 7 miles south of Benton and 3½ miles west of Hamil, a station on the Southern Pacific Railroad; elevation 5600 ft.; owner, Joseph B. Smith, Laws, Calif.; under lease to George Crawford, Bishop, Calif. The deposits are in Sec. 8, T. 3 S., R. 3 E., M. D. M.

These deposits are very extensive, possibly containing several million tons. The material is white to gray in color and rather fine, the largest pieces being about the size of a walnut.

The present lessee is making pumice blocks for construction of houses on the Indian reservation west of Bishop. About seventy-five cottages have been built to date.

Bibl.: State Mineralogist's Report XXIII, p. 404.

SODA AND SALT

The only soda produced in Mono County is derived from the waters of Lake Mono. The waters of this lake contain common salt, soda, borax and other soluble salts. The only production is a small amount of valuable medicinal salts obtained by evaporation of the water.

Lake Mono Salt Works. This plant is situated on the northeast shore of Lake Mono; owner, Wallace D. McPherson, Mono Inn, Mono Lake P. O., Calif.

The capacity of the plant is 250 pounds per twenty-four hours. The water from the lake is evaporated for the recovery of the salts which are sold for medicinal purposes.

TRAVERTINE

Bridgeport Travertine Deposits. These deposits are situated one mile southeast of the town of Bridgeport, on hilly slopes of andesite lava, 200 ft. to 300 ft. above the valley; owners, Chas. L. Hayes, Bridgeport, and Edward Dinnee, Oakland, Calif. Holdings comprise 60 acres which cover both springs and travertine deposits.

There are five prominent ridges of banded onyx marble or travertine, from 6 ft. to 15 ft. high and of somewhat greater thickness that tend to radiate from a central point. These ridges are cut longitudinally by a vertical crevice. The travertine is banded and stained various shades of red and yellow. The material has a pleasing mottled effect, is sufficiently translucent to give depth to the coloring and takes a good polish. The deposit is fifty miles from the nearest railroad point.

Several quarries have been opened up on the deposit and a carload of the material shipped to the Dinneen Marble Co., of Oakland, in 1926. Equipment consists of a derrick.

Bibl.: State Mineralogist's Report XII, p. 640; XV, pp. 173-174; U. S. G. S. Water Supply Paper 338, pp. 132-136.

TUFF

Extensive deposits of tuff suitable for building material occur in the volcanic tableland that extends from the Inyo County line to Benton Hot Springs. South of the Mono County line in Round Valley, Inyo County, this material is being quarried by the *Bly Stone Co.*, of Los Angeles.

The material in Mono County is being used locally by the ranchers in Hammil and Benton valleys in the construction of residences. When quarried the material can be taken out in large blocks and can be sawed into dimensions required for buildings.

MINERAL SPRINGS

There are a number of mineral springs in Mono County, the different hot springs in the northern and eastern portion being of considerable geologic interest. Some of these springs would become popular resorts were they accessible to a larger population.

Artesian Springs are located at Oasis, 30 miles northeast of Alvord, a station on the California and Nevada Railroad; elevation 5100 ft. Water is used for irrigation; owner, J. H. Forman, Oasis, Calif.

Bibl.: State Mineralogist's Report XXIII, p. 401.

Banner Spring. It is situated west of Benton, in the Inyo National Forest; elevation 7300 ft. Water is used for watering sheep.

Bibl.: State Mineralogist's Report XXIII, p. 401.

Benton Hot Spring. It is situated 300 yards northwest of Benton P. O.; elevation 5640 ft.; owner, William Bramlett, Benton, Calif.

The spring is approximately 10 ft. in diameter, in which the water has a temperature of 135° F. It has furnished a supply of water for the town for domestic and irrigation uses since 1862. Its discharge is approximately 400 gallons per minute. Quoting from a laboratory report made of the water by Smith-Emery Co., of Los Angeles: "The water is unique because of the absence of lime and magnesium salts, as well as an exceptionally low content of other mineral constituents. Medical authorities state that water free from lime and magnesium salts is beneficial in the treatment of certain diseases, such as gall stones, kidney stones and diabetes."

Bibl.: State Mineralogist's Report XXIII, pp 401-402; U.S.G.S. Water Supply Paper 338, p. 136.

Bertrand Ranch Springs are situated 6 miles east of north from Benton; elevation 5000 ft. Temperature of water is 70° F.; flow 100 gal. per minute. Used for irrigation.

Bibl.: State Mineralogist's Report XXIII, p. 402.

Black Lake Springs is situated 2 miles northwest of Benton; elevation 6425 ft.; owner, Peter Gilholt, Benton, Calif. The water is used for irrigation.

Bibl.: State Mineralogist's Report XXIII, p. 402.

Buckeye Hot Spring is situated about 5½ miles southwest of Bridgeport, on the north bank of Buckeye Creek; elevation 6950 ft. The water issues with a temperature of 140° F. and flows at about 25 gal. per minute. The water contains notable amounts of lime and a high amount of iron in solution. It is used for bathing.

Bibl.: State Mineralogist's Report XXIII, p. 402; U. S. G. S. Water Supply Paper 338, pp. 132-133.

Casa Diablo Hot Springs are on the lava slopes bordering Hot Creek, north of the main highway about 45 miles north of Bishop.

In a small depression some two hundred feet north of the highway formerly small amounts of vapor rose from a half dozen small pits. In one of these a bed of pink mud was kept in motion by bubbles of

steam. Temperatures ranged from 115° to 198° F. A few years ago a 6 or 8-in. drill hole was put down here and cased. Now a geyser spouts condensed steam continuously to a height of 60 ft. or 70 ft.

Bibl.: State Mineralogist's Report XXIII, p. 402; U. S. G. S. Water Supply Paper 338, pp. 146-147.

Geyser at Casa Diablo Hot Springs

Fales Hot Springs are situated 13 miles northwest of Bridgeport, on the road to Minden, Nev.; owner, Samuel Fales; elevation 7300 ft.

The hot water rises along the bed of a small creek which has been dammed to form a bathing pool. The temperature of the water issuing from the springs ranges from 129° to 141° F. It is reported to flow about 300 gal. per minute. Resort with hotel accommodations and cabins for camping parties.

Bibl.: State Mineralogist's Report XXIII, p. 402; U. S. G. S. Water Supply Paper 338, p. 132.

Mono Basin Warm Springs are situated at the east edge of Mono Lake; elevation 6425 ft.

Bibl.: State Mineralogist's Report XXIII, p. 402; U. S. G. S. Water Supply Paper 338, pp. 145-146.

Moran Spring is situated 13 miles southwest of Benton; elevation 7000 ft.

Bibl.: State Mineralogist's Report XXIII, p. 402.

River Springs are situated 10 miles northwest of Benton; owner, A. Matlick, Bishop, Calif.; elevation 6480 ft. Water is used for irrigation.

Bibl.: State Mineralogist's Report XXIII, p. 402.

Travertine Springs. This group of springs is situated 1½ miles southeast of Bridgeport, on the hilly slopes of andesite lava, 200 ft. to

300 ft. above the valley. Here are located a number of prominent ridges of banded onyx marble, 5 ft. to 15 ft. high and somewhat greater thickness. At two points near these ridges, small springs with temperature of 121° to 148° F. rise in pools about 3 ft. to 10 ft. in diameter. A third spring issues from a longitudinal crevice in the top of one of the ridges. Temperature is stated to be 148° F.

Bibl.: U. S. G. S. Water Supply Paper 338, pp. 133-135; State Mineralogist's Report XXIII, pp. 402-403.

Warner Hot Springs are situated one mile northeast of Casa Diablo Hot Springs and one-half mile northwest of the highway, 45 miles northwest of Bishop. Holdings comprise 6 claims, known as the Sulphate Group; owner, P. A. Warner, Los Angeles; elevation 7200 ft.

Two shafts were sunk to a depth of 10 ft. In the bottom of the shafts are vapor vents and some hot water. A number of hot springs are scattered over several acres of ground.

Bibl.: State Mineralogist's Report XXIII, p. 403.

Whitmore Tub Springs are situated in Long Valley, 3 miles west of Owens River and about 7 miles southeast of Casa Diablo Springs. There are two oblong pools a few feet apart and 40 ft. long in which warm water rises from which it flows to a shallow pond called Whitmore Tub. A new bathhouse has been built and the pools converted into a swimming tank.

Bibl.: State Mineralogist's Report XXIII, p. 403; U. S. G. S. Water Supply Paper 338, pp. 147-148.

GEOLOGIC BRANCH

CURRENT NOTES

By Olaf P. Jenkins, Chief Geologist

In the Next Issue

The results of field investigations on one of the first projects done in cooperation with the Geologic Branch is to appear in the next issue of the California Journal of Mines and Geology. This report, ''Geology of the Newberry and Ord Mountains, San Bernardino County'' by Dion L. Gardner, is accompanied by a geologic map of the area. It is supplemented by a report on the economic minerals of the same area, prepared by the Los Angeles District Engineer's office, and also by a shorter paper ''Notes on the Geology of a Portion of the Calico Mountains, San Bernardino County,'' written quite recently by Homer D. Erwin and Dion L. Gardner. The field work on the Calico Mountains was done largely by Erwin whereas that of the Newberry Mountains was done by Gardner.

In Press

Part One (Economics of the Oil and Gas Industry of California) of Bulletin 118 (Geologic Formations and Economic Development of the Oil and Gas Fields of California) is in press and should soon be ready for distribution. Part Two (Geology of California and the Occurrence of Oil and Gas) is nearly ready to go to press. This bulletin consists of contributions by a large number of professional men, well qualified to write on the subject assigned to them.

GENERAL GEOLOGY AND ORES OF THE BLIND SPRING HILL MINING DISTRICT, MONO COUNTY, CALIFORNIA*

By Alfred L. Ransome**

OUTLINE OF REPORT

* Thesis written in partial fulfillment of requirements for M. A. Degree in Geology, Stanford University, 1938.

** Staff Member, Geologic Branch, California State Division of Mines.

OUTLINE OF REPORT—Continued

ABSTRACT

The Blind Spring Hill Mining District is situated about 30 miles north of the town of Bishop, in the southern part of Mono County, California. The region surrounding the district is characterized by a series of Tertiary volcanics, including pyroclastic material and basalt, which is spread out over the eroded surface of pre-Cretaceous meta-sediments and Jurassic intrusive granitic rocks.

The mines on the Hill have been worked intermittently from 1862 until about 1929, producing approximately $6,000,000 worth of silver from complex ores of lead, copper, and silver, chiefly within 1,000 ft. of the surface in the zone of oxidation and secondary or supergene enrichment.

The orebodies occur as lenses in a system of parallel veins that have filled fault fissures in an intrusive igneous stock, varying in composition from a granite to a quartz diorite. These fissures all strike in a general north-south direction and dip to the east about 40°. Faulting of the veins by a system of east-west fissures of post-mineral age has not resulted in any serious displacement of the orebodies.

A system of aplite dikes running parallel to the veins is genetically connected with them, and indicates mineralization from a magmatic source. This indication is further substantiated by the type of mineralization. The commercial ore is formed chiefly through secondary enrichment of the primary sulphides. Stromeyerite, the most important silver mineral, makes up the bulk of the "black metal" ore.

The deposit is of the mesothermal type, and shows indication of decrease in silver content in the ore with increase of depth.

INTRODUCTION

LOCATION

The Blind Spring Hill Mining District is in the southeastern part of Mono County, California, near the California-Nevada state line. It is situated about 30 miles southeast of Mono Lake and about the same distance in a northerly direction from Bishop, the largest town in the region.

A good paved road from Bishop to Montgomery Pass runs past the east slope of Blind Spring Hill, as does the narrow-gauge Carson and California Railroad. Secondary roads and wood roads are numerous, making nearly all the area accessible by car. From Benton, a narrow road which can be negotiated by automobile winds up the west slope of the hill to the various mining properties on top.

The mining district proper is an area about two miles square, located near the center of Blind Spring Hill.

The general mapped area surrounding the Hill, which includes parts of the Mt. Morrison and White Mountain quadrangles, forms a rectangle extending approximately 3 miles north, 6 miles south, 5 miles east, and 3 miles west of Benton.

HISTORY

Various sources of information differ slightly as to the historical facts concerning the district, but it seems there is agreement as to the discovery of silver on Blind Spring Hill in 1862. The discovery vein was named the Cornucopia. Within a few days the Diana, and then the Kerrick and Comanche veins were located. A general stampede resulted, and soon the entire mountain was covered with locations. It is said that within a year of the Cornucopia discovery, a town of more than 3,000 people sprang up near Benton Hot Springs and what is now Benton.

In 1863 or 1864, the district was legally organized, and claims were limited to 200 ft. along the vein and 100 ft. on each side of the apex. As a result, the mines were worked in a generally confused, non-systematic manner; but eventually, under the United States laws of 1872, which fixed the size of the mineral claims to 1,500 ft. long by 600 ft. wide, not affecting prior claims, the mines of the district for the most part were consolidated.

In 1880 or 1881, all the producing mines passed into the control of an Australian manager, who operated them by means of the leasing system. As a result, most of the mines were gutted of high grade ore without any projected development work to insure possible future production. From this time on, the production of the camp fell rapidly, and ceased entirely at the death of the Australian operator. Chinese miners took over some of the mines and cleaned up what the lessees had left, robbing the pillars and caving the levels, rendering some of the workings dangerous and in some cases, inaccessible.

The company that secured the mines from the estate of the Australian operator undertook the driving of a tunnel under the hill which would cut the veins of the group, thus enabling all the mines to be worked from one long main artery (known as the Transportation

or Ross tunnel). This tunnel project was not completed because of apparent mismanagement, and work was abandoned after having progressed about 1,600 ft. without cutting any of the mineralized veins.

The present Comanche Mining and Reduction Company took over the Comanche group of mines in 1917, and also acquired the Diana-Kerrick, Cornucopia, and Borasca mines, and all of these properties have been more or less under development until about 1929. Since that time little work has been done, although some silver has been recovered by occasional leasers permitted by the company to work small grass root mines. At the present time (1940) a custom mill is in operation on the east slope of Blind Spring Hill, and ore from the Kerrick workings is being treated.

The total production of the district to date is not definitely known, but is estimated as being from $4,000,000 to $6,000,000, more than one-half of this amount having been produced by mines now owned by the Comanche Mining and Reduction Company. All of the mines were richest near the surface, and none were worked to depths greater than 800 or 1,100 ft. below the ground surface.

PHYSIOGRAPHY

Elevations vary from about 5,000 ft. near the Mathieu Ranch on the southeast slope of Blind Spring Hill to about 8,200 ft. in the west part of the basalt flow in the Benton Range. Blind Spring Hill, with an elevation at its highest point of a little over 7,200 ft., is the most prominent topographic feature in the area. Rising abruptly from the coalescing alluvial fan-filled graben valley on the east, and with not quite such a steep slope from Blind Spring Valley to the west, the Hill stands alone with a relief averaging 1,500 ft. from the valleys on either side. In reality, Blind Spring Hill is not a hill, but a long ridge extending for about six miles in a general north-south direction, having a maximum width of about three miles.

The Benton Range, although higher, has a more gentle slope from Blind Spring Valley, and is continuous for many miles in a north-south direction generally parallel to Blind Spring Hill.

The area as a whole has not advanced to any great extent beyond the youthful stage in the erosion cycle. This condition is shown by the rather rugged hills, still downcutting V-shaped canyons, and especially by the fact that the lava flow remains practically as it was laid down, with very little dissection by streams. Even the comparatively soft beds of pyroclastics have not been cut away to any marked degree.

Drainage in the area is taken care of by intermittent streams, the main one of which is an unnamed wash in the valley east of Blind Spring Hill through which water flows at times, draining all the creeks from the White Mountains to the east. Benton Valley drains into this same wash from around the north end of Blind Spring Hill. The southern section of the area is drained by intermittent tributary streams which pass through a canyon east of Yellowjacket Spring. The valley just west of the Benton Range is drained by another unnamed intermittent stream which flows north into Black Lake, shown in the northwest corner of the area, which has no outlet. There is water in the lake the year around, which has for its source several springs in the vicinity in addition to the drainage from winter snows.

About a mile south and east of the lake in a line directly west of the town of Benton, there is a gap in the Benton Range, cut by headward erosion of an intermittent stream flowing east into Blind Spring Valley. This gap at the present time is cut almost down to the level of the stream feeding Black Lake, and is an excellent example of nearly completed stream capture. The drainage of Black Lake Valley will, upon further headward erosion of the capturing stream, proceed eastward to the stream east of Blind Spring Hill.

In general, the region would be termed semi-arid, the annual precipitation, including rain and snow, being sufficient to place it in this category. The altitude of 5,000 ft. and over keeps the average temperature well within the range of comfort during the summer months. During the winter, snow covers most of the area, especially in the western part, and this snow is the primary source for the water in the streams.

SETTLEMENT AND INDUSTRY

There are two small communities in the area. Benton Station, about a mile east of the northern tip of the Hill on the highway and railroad, is populated only by the few people who run a store, gasoline stations, garage, and the freight depot. Benton, in Blind Spring Valley about two miles west of the Hill, is the Post Office for the surrounding region, and has a general store, hotel, and school. Only a few families actually live in the town; the population is less than a hundred.

A few ranch houses are scattered over the area, especially on the valley floor east of the hill.

The Indian population in the area is comparatively large, primarily self-supporting families that have moved from the reservation a few miles to the south.

Mining has largely declined in this district in the past years; and at the present time is confined to the working of small properties and prospects producing silver, gold, and some tungsten. It still may be considered the dominant activity. The production of pumice has largely ceased in this district, but is still being shipped from properties a few miles to the south.

On the few large ranches in the district, alfalfa is produced and stock is raised.

The management of the store and hotel in Benton makes use of the natural hot spring water for curative baths in conjunction with the hotel.

BIBLIOGRAPHY

Reports on the geology and mining of the Blind Spring Hill District are meager. Little or no record was kept in the earlier days of mining, and all available information consists chiefly of brief descriptions in the California State Mineralogist's Reports VIII, p. 376; X, p. 338, XII, p. 374; and XXIII, p. 391. The only references to the "mineral" Partzite were found in: American Journal of Science, Vol. 93, p. 362. 1867; and vol. 94, p. 119. 1867.

The following private reports were obtained through the courtesy of the Comanche Mining and Reduction Company:

Pernot, P. H.: Report on the Comanche Mine, Benton, Mono County, California. (revised) June 1, 1920.

Pernot, P. H.: The Diana-Kerrick-Cornucopia Group of Mines, Blind Spring Hill District, Mono County, California. June 15, 1920. Los Angeles, California.

Tucker, W. B.: Report on Property of Comanche Mining and Reduction Company. March 5, 1929. Los Angeles, California.

SCOPE OF REPORT

Not much has been done in this region in the field of original detailed geological investigation in the years past, and the only record or description of the district in the earlier years of mining is found in the State Mineralogist's Reports. The only geological study of the Hill, as far as can be ascertained, was made by P. H. Pernot in 1920, which was presented in a private report for the Comanche Mining and Reduction Company. This report is detailed with respect to fault problems but evidently only a few, if any, thin sections of rocks were made; and it is likely that no polished surfaces of ore specimens were studied.

It is this apparent lack of microscopic investigation of the ores and country rock of the district that forms the basis for the present geological investigation, which includes the study of the rocks of the area, and the ores of the district, their mode of occurrence, and how they were formed.

The investigation was begun by a general review of the available literature concerning the district including such reports, data, and maps which were obtainable from the Comanche Mining and Reduction Company. A visit was made to Blind Spring Hill to look over the area and obtain specimens of the ore. Some of these specimens were collected from the ground, but the majority were obtained from a large collection in the possession of Mr. C. D. Woodhouse. These, including some from other sources, were studied during the spring of 1935. Thin sections were made of the country rock for petrographic study. During the summer of 1935, three weeks were spent in the field during which time the writer made a reconnaissance survey of the geology of the area. Geological study in underground workings was limited to a few small adits and prospect pits, as the major workings from which ore was formerly taken were for the most part not in condition to be entered with safety due to caving and bad ventilation.

ACKNOWLEDGMENTS

The writer is indebted to Mr. C. D. Woodhouse for suggesting the study of the Blind Spring Hill area, and for his loan of many ore specimens without which this would have been handicapped; to Mr. G. W. Adams, President of the Comanche Mining and Reduction Company, for his cooperation and help in enabling the writer to study on company property and for the use of various reports and maps of the district; and to Mr. W. B. Tucker, District Mining Engineer, California State Division of Mines, for the use of specimens from his collection as well as helpful discussion of the problem.

To Professor C. F. Tolman, under whose guidance this thesis was completed, the writer is indebted for many helpful criticisms and suggestions during the laboratory work on the ores of the district and for the final assembling of material. Many thanks are also due to Professor A. F. Rogers and Dr. L. W. Staples for their help in the photographing of thin sections, and for their suggestions in the use of microchemical tests.

GENERAL GEOLOGY

GEOLOGIC HISTORY

The early geologic history of the district is shown only in meager detail in the few remaining patches of what were originally sedimentary rocks. The age of these rocks is questionable but they are undoubtedly pre-Cretaceous. Across the valley to the east, in the White Mountains is an incomplete series of sediments dating from the Cambrian to the Cretaceous. It is probable that similar sediments, since eroded, were deposited in the Blind Spring Hill area.

During the late Mesozoic mountain-building epoch, at which time the great batholithic intrusions took place along the Pacific coast, the land was uplifted. Accompanying and following this mountain-building epoch was a period of ore-forming designated by Lindgren as the third or late Mesozoic metallogenetic epoch.[1] The deposits of Blind Spring Hill are undoubtedly of this epoch and are considered to be mesothermal.

Subsequent to the uplift a long period of erosion took place which practically stripped the overlying sediments from the granitic intrusions, leaving them exposed.

It was upon this eroded surface that the thick deposits of pyroclastic material were laid down, to a large extent in water, and finally capped by the flow of basalt. This represents the last phase of igneous activity which occurred during the orogenic epoch of the late Tertiary. It was during the final stages of this crustal movement, after the volcanic activity, that major block faulting took place.

During the Pleistocene and Recent times the action of intermittent surface streams has produced the only changes in the topography; this action in the Benton area has not proceeded to any marked degree. The greatest visual result is the series of large coalescing alluvial fans issuing from the deep V-shaped canyons of the White Mountains. These fans fill and spread out across the entire valley east of Blind Spring Hill.

SEDIMENTARY ROCKS

Terrace Deposits

Covering nearly half the mapped area, a mantle of pyroclastic ejectamenta fills all of Blind Spring Valley and nearly all topographic depressions. This material has, to a large extent, been deposited in water, and in certain parts of the area, particularly around Black Lake and Yellowjacket Spring these deposits form distinct terraces. For this reason these beds of pumice, and tuff have been mentioned under the heading of sedimentary rocks. A more detailed description is

[1] Lindgren, W., Mineral Deposits, p. 890.

given under igneous rocks, a classification that more correctly fits their origin. The age of this series is considered to be later Tertiary or early Quaternary on the basis of the accepted age of the volcanic series of Mono County of which these deposits are a part.

Recent Alluvium

The largest area of recent alluvial deposits is to be found in the series of large coalescing fans that spread out from the White Mountains, covering the floor of the valley. Other patches of Recent alluvium cover the floor of Blind Spring Valley, the valley floor extending from Black Lake, and a small flat valley near Wildrose Canyon.

METAMORPHIC ROCKS

Several small patches of metamorphosed sedimentary rocks are found near the southern edge of the mapped area, altered through contact with the igneous masses. The general structure of the rock is schistose, varying from almost a phyllite to a type similar to a gneiss. In all cases the bedding is prominent with a varying dip in a generally east direction. The color ranges from a brownish-gray to gray, the brown undoubtedly due to weathering. The grain size varies from quite fine in the phyllitic type to coarse in the gneissic type.

The age of these altered sediments is questionable, but as they were undoubtedly metamorphosed through contact with the granitic intrusives of Jurassic age, the series can best be termed as undivided pre-Cretaceous metamorphics.

IGNEOUS ROCKS

General Features

The Blind Spring Hill District and surrounding area as defined on the geologic map lies east of the main body of the great Sierra Nevada batholith, and is on the northeastern edge of what is designated "Volcanic Tableland", an area just north of Bishop. This volcanic tableland is itself a small portion of a much larger area extending northward and eastward from the Sierra Nevada, comprising a great zone of former eruptive activity centering around numerous volcanoes and cinder cones, the main and largest group of which is known as the Mono Craters. These craters are located on the south shore of Mono Lake, extending south for several miles, and are situated in nearly the geographical center of Mono County.

The result of this widespread volcanic activity is apparent in the area around Blind Spring Hill where igneous rocks form the foundation for almost the entire geology of the area.

The igneous rocks in the area can be classified into two major groups: Jurassic intrusives, the source of mineralization, and Tertiary extrusives, the latter being the product of the aforementioned volcanic activity having no relation to mineralization. These two groups can be subdivided as follows:

Group I	*Group II*
Jurassic Intrusives	*Tertiary Extrusives*
Granitic type	Pyroclastics
Dike rocks	Basaltic lava

The granitic type of rock is the basement material of the area and forms the higher hills and prominent ridges. Where exposed, the results of weathering are generally quite evident, the surface being rather soft and crumbly. This is especially noticeable in the Benton Range.

The volcanic ash, breccia, and tuff, for the most part is found in the valleys and in depressions eroded in the granite. The basalt occurs as a flow on top of the eroded granitic surface.

Jurassic Intrusives

Porphyritic granodiorite

Of the granitic type of rock under Group I, the porphyritic granodiorite occurs in greater amount than all the rest. The Benton Range is composed almost entirely of this rock, with the exception of local areas where the phenocrysts are either lacking or not of sufficient size to term the granodiorite porphyritic. This mass in the Benton Range extends across the entire area in a north-south direction, varying in width from one-half to three miles. Other smaller masses and ridges parallel the larger mass.

Blind Spring Hill is composed largely of this same porphyritic granodiorite, the greater portion of which occurs along the western half of the Hill.

Hornblende granite

This rock, as well as the remaining types under Group I, is found on Blind Spring Hill. The granite is similar in appearance to the porphyritic granodiorite, with the exception that phenocrysts are lacking. It is hard to define the boundaries of this rock, as there is no definite borderline between it and the porphyritic granodiorite on the west side of Blind Spring Hill, and quartz diorite to the east. The granite may be found along the top of the Hill and partly on the east slope.

Granite (Alaskite)

This rock is more of the true granite, with the exception that the dark ferromagnesian minerals are practically absent. Specimens of this rock were obtained from the top edge of the transportation tunnel dump, and from the position of the rock in the dump, it would appear to be the last country rock encountered before the tunnel was abandoned. If such is the case, the granite could be placed in nearly the center of the Hill at the end of the tunnel near the bottom of the Kerrick Incline, and approximately beneath the hornblende granite outcropping above. As it was impossible to enter the tunnel to make observations, the deduction may be incorrect and in any case the actual width, lateral extent and contacts of the previously mentioned rock types were impossible to obtain and can only be surmised.

Quartz diorite

On the east slope of Blind Spring Hill, the major part of the rock is comprised of quartz diorite which seems to occur as a parallel mass to the hornblende granite, with no definite line of contact between the two.

Dike Rocks

Aplite. Running in a nearly north-south direction along the northern half of the Hill, white colored aplite dikes are very noticeable. Being very hard and fine-grained, they withstand weathering and project above the surrounding rock. These dikes are more or less confined to the mineralized area; but unlike the mineralized veins described later, they have a nearly vertical dip, usually slightly to the east, sometimes to the west. The width varies from a few feet up to as much as 25 feet.

Diabase. Numerous dark greenish-gray colored dikes run in a north-south direction generally parallel to the aplite dikes, and have a rather steep dip usually to the west. These dikes are not so prominent as the aplite, and vary in width from about two to six feet; they are confined to Blind Spring Hill, primarily in the mineralized area.

Lamprophyre. The remaining series of basic dike rocks occurring on the Hill is very fine-grained gray-black rock which strikes nearly east-west, and at right angles to and cutting the earlier above mentioned dikes. The dip is at a very high angle, inclining a little to the north.

Tertiary Extrusives

Pyroclastics

In Group II, all the volcanic ejectamenta other than basalt are termed pyroclastics. These include volcanic ash, andesite tuff, rhyolite tuff, and pumice. Taken collectively, this pyroclastic material covers nearly half the mapped area, filling in all the valleys west of Blind Spring Hill and most of the topographic depressions.

Perhaps the most striking characteristic of this material shows that at least a large percentage of it has been deposited in water, some having been transported by water. In nearly every case where outcrops are exposed to any extent vertically, the material has been formed in horizontal beds which show a rather remarkable degree of sorting. The tuffaceous material in this case does not show the sorting to any marked degree; but there are numerous varying sizes of waterworn quartz pebbles, from one-fourth to one-half inch in size, included in the tuff, which though not in itself conclusive, suggests the action of water. The tuff has a color varying from white to pinkish red, and is evidently andesite, being composed of small but well defined crystals of andesine feldspar, biotite, a little hornblende, occasional quartz, fragments of frothy pumice, and a few fragments of obsidian.

In the southern part of the area, near Yellowjacket Spring, the pyroclastic material is composed of almost pure white pumice. In fact, there have been several ventures in the nearby vicinity of the spring toward mining this material.

The evidence of the action of water here is unmistakable. The sorting is very good and the "pebbles" of pumice are confined to quite definite horizontal beds varying from a few inches to several feet in thickness.

The final evidence showing deposition of this tuff and pumice in water indicates that such deposition took place in the still waters of lakes. Black Lake is located in the northwest corner of the area in the bottom of a rather long, shallow basin filled with andesite tuff and

pumice. That this lake is merely a small remnant of a larger body of water is evidenced by the presence of terraced tuff beds covering the granite on the east bank of the lake, there forming a well defined contour about 100 ft. above the present water level.

Olivine basalt

As can be seen on the Geologic Map, the basalt flow covers about six square miles of area southwest of Benton. The basalt originated from the west, and now remains as a cap covering the granite and volcanic ash on the east slope of the Benton Range with a rather small dip varying from about 5 to 10 degrees to the east. The thickness varies from 25 ft. and more to only a few feet near the borders. The surface is rough, blocky, and not weathered to any marked degree. In certain places columnar structure is present, and throughout the flow there is definite gradation vertically from dense aphanitic in the center, to vesicular basalt at the top.

Geologic Relationship of Igneous Rocks

There is not much doubt that the intrusive granodiorite masses of the Benton Range and parallel ridges are associated with the main mass of the Sierra Nevada batholith. Blind Spring Hill, with its various types of granitic rocks varying from granite to quartz diorite, is probably connected with the same deep-seated intrusive mass, and may be termed a stock. The change of rock types and chemical and mineral composition in the main body of the stock is probably due to differentiation in the cooling magma.

The aplite and diabase dikes run parallel in a north-south direction, and there was no indication of one system cutting the other, at least at the surface, and there is no way to connect the two together genetically other than the probability of origin from the same source at different times. The lamprophyre dikes running east-west are evidently the last emanations from the stock, as they cut the former dikes and cause minor displacements of only a few feet.

The intrusion of the granodiorite and allied granitic rocks of the Benton Range and Blind Spring Hill is probably contemporaneous with the Sierra Nevada batholith which would place it as being late Jurassic or earliest Cretaceous time. The intrusion of the aplite and diabase dikes followed shortly after, the aplite primarily being the last acidic emanation of the cooling magma. The lamprophyre dikes followed at some later date after the mineralization took place.

The volcanic ejectamenta, including all the pyroclastic material, were deposited in the late Tertiary during the general volcanic disturbances along the entire Cordilleran region, a small section of which is represented by the rocks in the area. The basalt is one of a series of flows that occur elsewhere in the region interbedded with the pyroclastics. Just what part of the series is represented in the area is not known, but the basalt is the last and most recent volcanic ejection in the Blind Spring Hill area.

STRUCTURE

FAULTS

The structure is fairly simple. In general, it consists of the basement granitic mass overlain in topographic depressions by the tilted remnants of the metamorphic sedimentary series unconformably overlain by nearly flat lying beds of pyroclastics capped by the basalt flow. Faulting on a major scale has occurred in two zones in the area, with a considerable local faulting with small displacement on Blind Spring Hill.

The Blind Spring Hill stock is an uplifted block defined by faults on both sides of the Hill. The Hill fault strikes along the base of Blind Spring Hill on the east side. Although local displacement evidence of this fault is lacking, the abrupt east slope, the presence of alluvial fans, and the fault line scarp along the west front of the White Mountains across the Owens Valley, all point to regional block faulting. The Benton fault on the west side of Blind Spring Hill defines the west slope of the uplifted block. That the displacement is not as great as the Hill fault is indicated by the higher elevation of Blind Spring Valley above Owens Valley.

The second zone of faulting is along the west slope of the Benton Range and includes two well defined faults striking in a general north-south direction roughly parallel to the Blind Spring Hill block. The most northerly fault in this zone, called the Black Lake fault, follows a general course along the west slope of the Benton Range and east of Black Lake. The most convincing local evidence of movement along this zone is given by the stream capture of the Black Lake watershed.

In the southwest corner of the mapped area in the same second zone is located the Wildrose Canyon fault. This fault is traceable only for about two miles, but is very distinct. No better evidence for a fault could be asked than is shown in this case, where the basalt flow is displaced vertically from about 50 ft. more or less at the south edge of the flow to about 400 ft. or more at the northern edge. The fault had a rotating motion with the greatest movement toward the north. The movement was essentially vertical, with the upthrow side on the east. The exact age of these fault movements is somewhat in doubt, but it may be correctly assumed that they all resulted from the widespread Sierran crustal movement of the late Tertiary and early Quaternary. In their age relation with one another, the Hill, Valley, and Black Lake faults are probably contemporaneous or nearly so, their movements taking place prior to the deposition of the pyroclastics as there is no structural evidence in this series to indicate a post deposition movement. The Wildrose Canyon fault movement came at a somewhat later date, as shown by the displacement of the basalt, and is the last major faulting to occur.

Almost, all of the numerous faults on Blind Spring Hill are related to the period of mineralization, considered to be late Mesozoic, and can be divided into two classes, pre-mineral and post-mineral. Nearly all the intrusive dikes have apparently come up through fault fissures, and it is evident that the mineralized veins are of the filled fissure type. The system of east-west dikes, the latest intrusions on the hill, also are in fault fissures as shown by the fact that they cut the former dikes and

displace them. Some of these small fissure faults were not filled with dikes, at least there is no indication of such intrusions at the surface.

The greatest displacement of any of these small faults does not appear to be more than about 150 ft., and is usually only a few feet up to about 30 ft.

Most of the movement was normal with occasional reverse faulting of a few feet. That some of the post mineral movement displaced veins is evident, but not to any marked degree. The map of the Cornucopia Mine, made by Bronton compass survey, gives an idea of the number of small fissures and faults, their tread, displacement wherever it could be noted, and the influence on the vein of ore.

METAMORPHISM

Metamorphism when restricted to the contact alteration of sediments and excluding such rock changes as are related to the formation of the mineralized zone on Blind Spring Hill, is of relative unimportance geologically in the area. Only three small zones of meta-sediments show in the geologic map, all of which are south of the Hill.

The contact of the intrusive igneous granitic rocks with the sedimentary rocks produced a marked alteration near Yellowjacket Spring. Practically all the overlying rock was garnetized to such an extent that the original rock type is unrecognizable. The bedding planes are still present and generally well preserved. Other sedimentary rocks have been changed from the original into mica schist, in some instances phyllite, and occasionally almost into gneiss.

About eight miles south of Benton in the contact metamorphic area (not shown on the map) there is an occurrence of scheelite in a mineralized zone in what has been termed tactite.

ORE DEPOSITS

MINERALOGY

The ores in this district are made up of lead, copper, and silver-bearing minerals. All the species are generally common minerals with the exception of the copper-silver sulphide, stromeyerite, the occurrence of which is rather rare compared with that of the others, and which provides the chief source for the silver in the district.

Gold. Nearly all the assay returns for the mines on Blind Spring Hill show a small amount of gold, but examination of the ores including polished surfaces showed no trace of gold present. Small amounts of free gold have been recovered from gravels in the western part of the area, and several small mines in the granite of the Benton Range have recovered gold from quartz veins in the years past.

Silver. Native silver occurs in small amounts throughout the upper oxidized zone and is associated with malachite, azurite, copper pitch, and small amounts of what remains of the original "black metal." Usually the silver is in the shape of small thin flakes, easily rubbed or broken off from the surface of the specimen.

Galena. The isometric lead sulphide (PbS) is one of the most common ore minerals in the district. It occurs in massive form, both

cleavable and granular; and in some instances as a rather peculiar, very fine series of laminations which show none of the typical galena cleavage, even on a polished surface under the microscope. The galena has a wide vertical range, occurring not only in the lowest levels that have been mined, but throughout the oxidized zone and even in the surface outcrops. It was noticed that in general the coarser cleavable galena is present nearer the surface, while the fine laminated occurs at depth. This does not always hold true, however, and there does not seem to be any constant relation concerning this difference.

Pyrite. Iron sulphide, pyrite, is very common in the district, but is an unimportant constituent of the ores. Practically every type of igneous rock to be found on Blind Spring Hill has small specks of pyrite included in it, some of which are formed in the rock by alteration of iron-bearing minerals and some by the metasomatic process, pyritization. In the veins, especially in the siderite, small cubes of the mineral are common. It is also present in small amounts in the galena and tetrahedrite.

Chalcopyrite. In the lower workings, this copper sulfoferrite is encountered, but does not occur in large amounts. Occasional small masses are found in lenses with the tetrahedrite; and small irregular masses contained in both galena and tetrahedrite, show up clearly on a polished surface.

Bornite. This copper sulfoferrite has been reported as being present in the district. None was noticed by the writer on any specimens examined from the district.

Chalcocite. This black sulphide of copper is found only in small amounts in the veinlets cutting through the tetrahedrite. It is formed through alteration of the ''gray copper'' and produces what has been termed ''chemical brecciation'' of the tetrahedrite.

Covellite. An alteration product of the chalcocite, this blue-black sulphide of copper is found along with the chalcocite in the small veinlets cutting the tetrahedrite.

Stromeyerite. This rather infrequently occurring mineral is, in this district, the principal silver mineral. Stromeyerite $(Ag, Cu)_2 S$, is closely allied to chalcocite and is known to occur both as hypogene and supergene.[1] In the deposits of this district, the occurrence is evidently supergene.

The only associated minerals with the stromeyerite are tetrahedrite and galena, and the mixture of all three together produces the rich ore known as ''black metal,'' which occurs as lenses in the veins primarily in the lower part of the oxidized zone.

Argentite. This silver sulphide has been reported, but was not found on any specimens examined.

Sphalerite. A small quantity of this zinc sulphide was found occurring with the tetrahedrite. It is not an important ore mineral.

[1] Lindgren, W. Mineral Deposits, page 860.

ILLUSTRATIONS FOR REPORT

By Alfred L. Ransome

DESCRIPTIVE GEOLOGY AND ORES OF THE BLIND SPRING HILL MINING DISTRICT, MONO COUNTY, CALIFORNIA

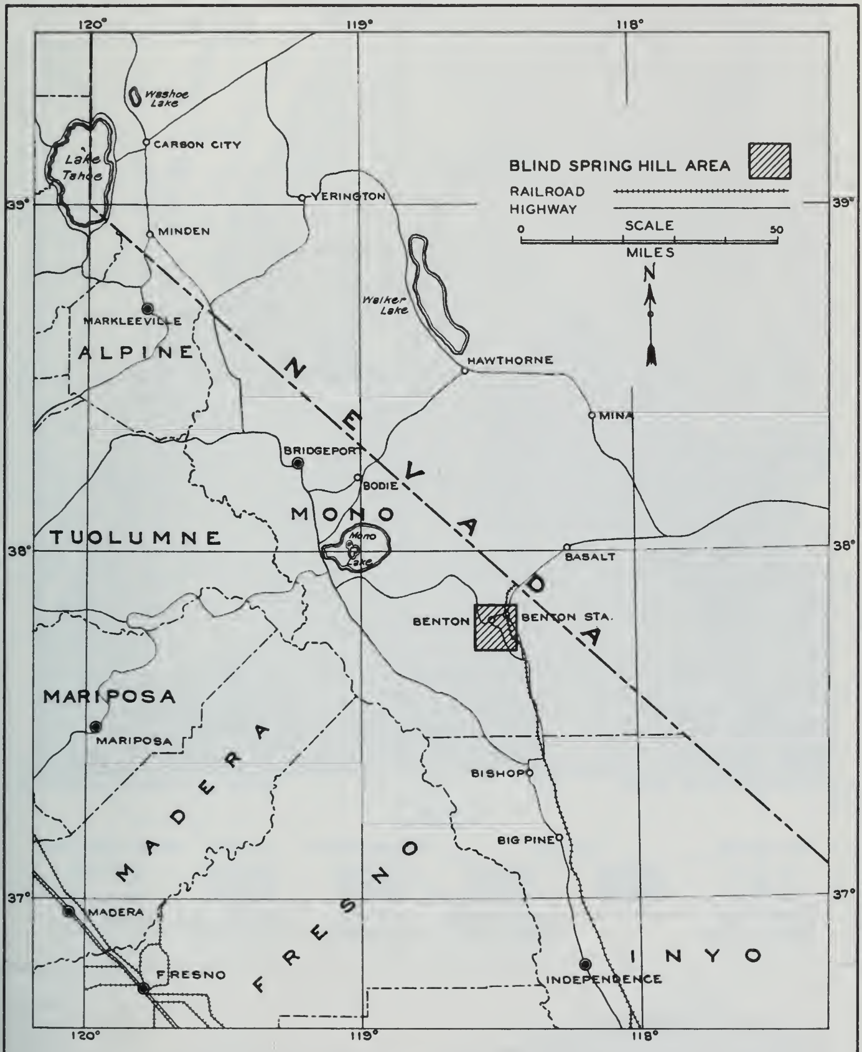


Fig. 1. Location map, showing area covered by this report on the Blind Spring Hill Mining District.

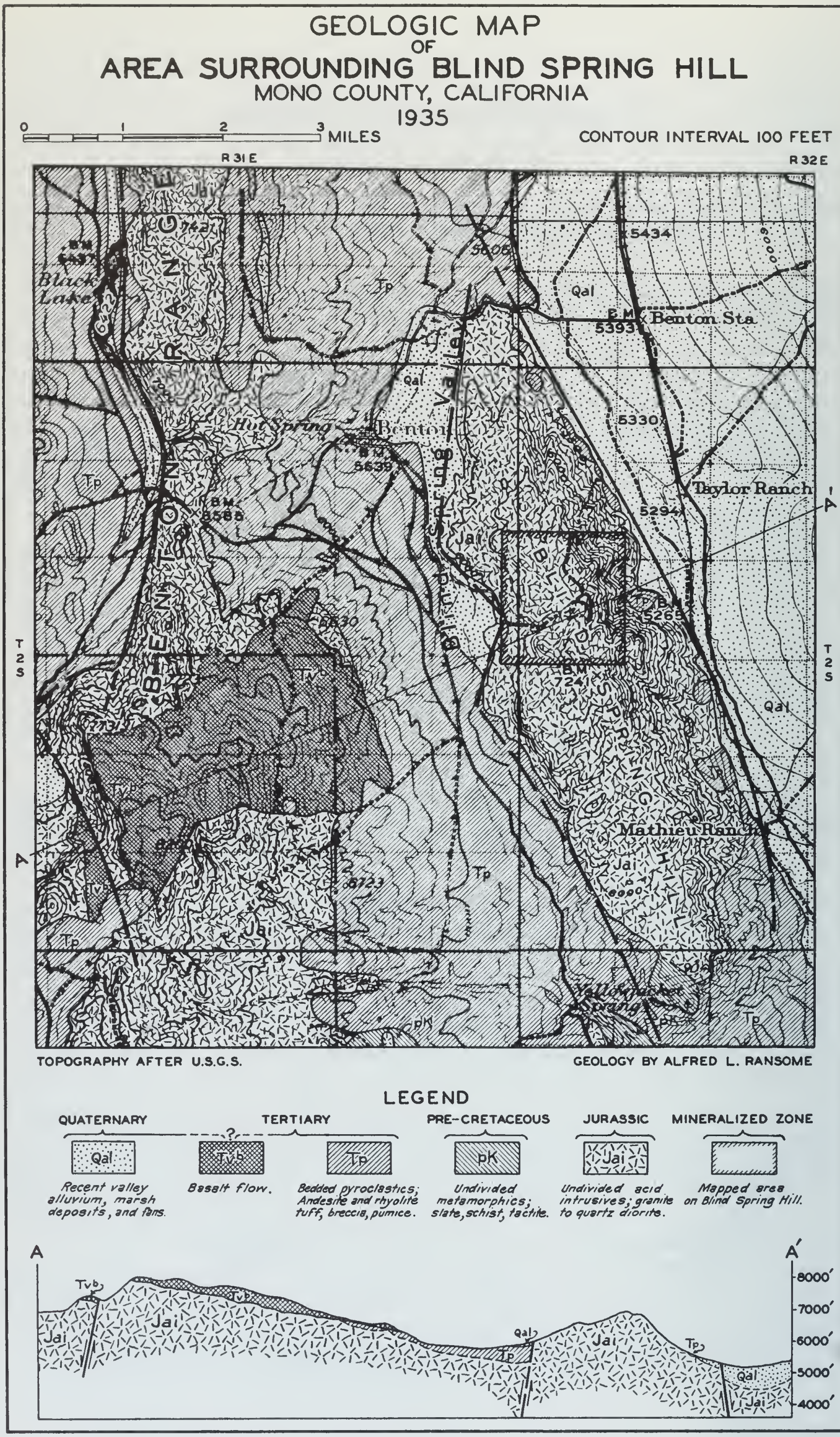


FIG. 2. Geologic map of area surrounding Blind Spring Hill.

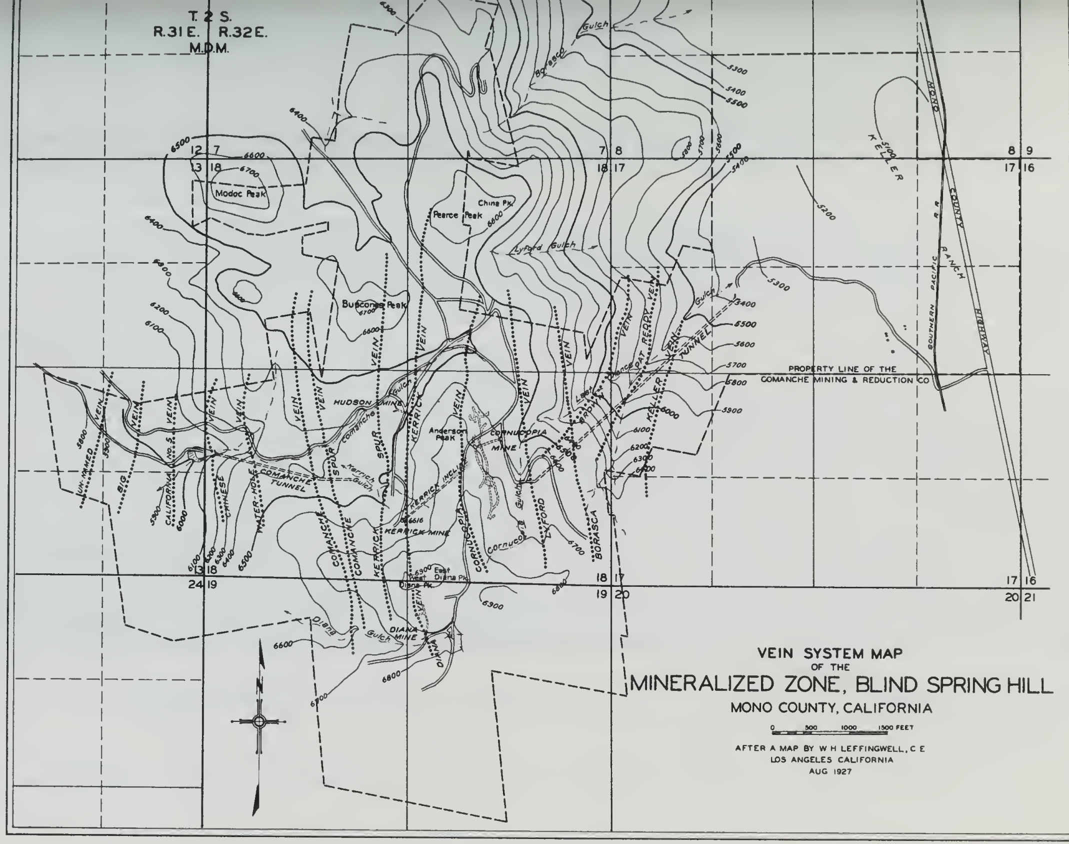


FIG. 3. Map showing vein systems in the mineralized area on Blind Spring Hill as indicated on geologic map (Fig. 2). The orebodies occur as lenses in this system of parallel veins that have filled fault fissures in an intrusive igneous stock, varying in composition from a granite to a quartz diorite. These fissures nearly all strike about north and dip east about 40°. Faulting of the veins by a system of east-west fissures of post mineral age has not resulted in any serious displacement of the orebodies.

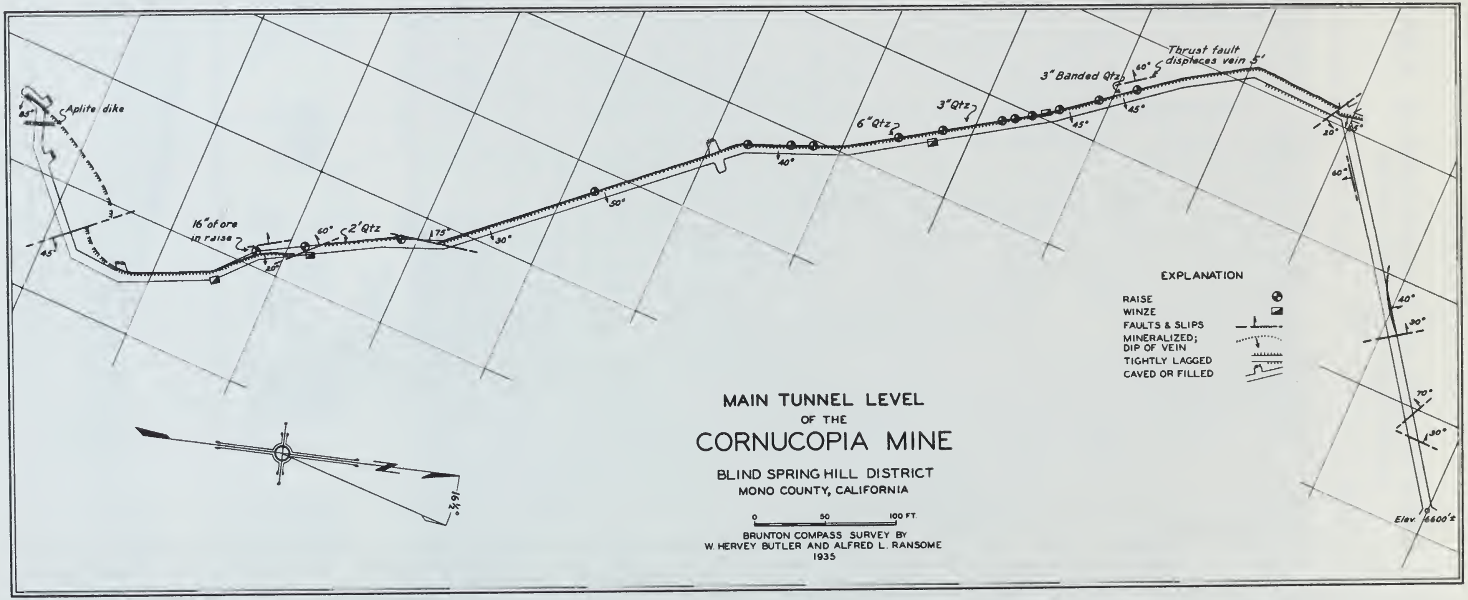


FIG. 4. Main tunnel level of the Cornucopia mine. Mining on the Cornucopia vein started from the grass roots; this is the first level below the surface. The map shows the numerous small slips and faults encountered and the negligible displacement of the vein which itself is a mineralized fault fissure. This vein is characteristic of the entire system on Blind Spring Hill.

FIG. 5. Panoramic view looking east across Blind Spring Valley to the snow-capped White Mountains. Blind Spring Hill is outlined in the middle distance. The town of Benton can be seen in the valley to the left.

FIG. 6. View looking south from about the center of the mineralized portion of Blind Spring Hill along the Kerrick vein. The large dump in the right center is from the Kerrick incline. Diana Butte is shown as the twin peaks in the background. The old Diana workings are over the butte on the south side.

FIG. 7. Looking north from the same spot as Fig. 6. At the extreme right center can be seen the small dump and track leading from the Hudson workings on the Kerrick vein. On the far slope are numerous small dumps indicating prospect holes which dot the mineralized area on Blind Spring Hill.

FIG. 8. View to the northeast across Black Lake. Above the lake on the west slope of the Benton Range are terrace deposits of pyroclastic material composed of volcanic ash and pumice and andesitic tuff. The dashed line indicates the probable line of the Black Lake fault.

FIG. 9. View looking east through gap in Benton Range (due west of Benton). This gap formed by headward erosion of small intermittent stream will eventually capture the present stream flowing into Black Lake which is beyond the left edge of picture. The dashed line indicates the probable line of the Black Lake fault.

FIG. 10. North-south striking aplite dike west of the Kerrick vein. View toward the south. The width of the dike, which dips about 85° east, is 20-25 feet.

FIG. 11. Outcrop of basic dike near China Peak, Blind Spring Hill, about the north edge of mineralized area. The width varies from 4 to 6 feet; the strike is nearly north-south with a steep dip to the west.

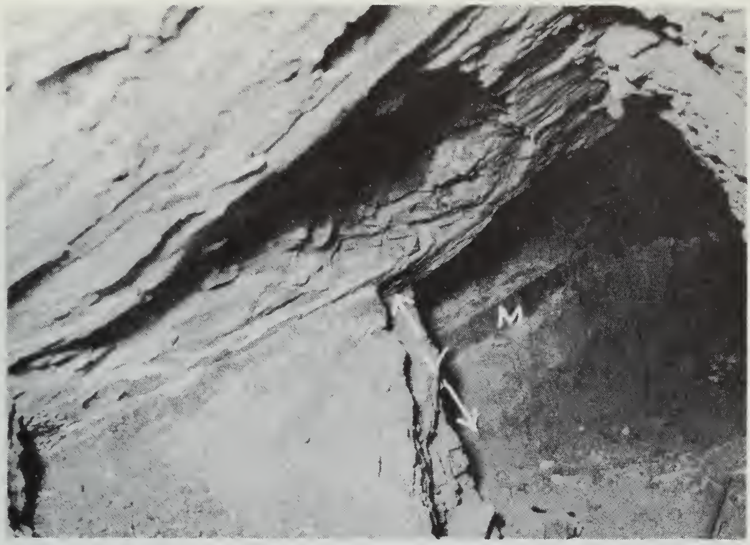


FIG. 12. Underground photograph in the main adit of the Hudson workings on the Kerrick vein. Arrows show the limits of the vein (V) having at this point a width of approximately 2½ feet. The strike is in a north-south direction with a 40° dip to the east. Granodiorite forms both the hanging and footwall. Slickensides shown on the hanging wall indicate movement in the direction of the dip of the vein. The dark colored band (M) is the mineralized portion of the vein which carries the silver-bearing minerals.

FIG. 13. Closer view of vein and mineralized zone (M) as shown in Fig. 12. There is a distinct boundary between the mineralized band and the remaining vein filling which also shows some mineralization. This mineralized band is primarily quartz which at this point is 8 inches or less in width. The general position of the quartz band in the vein has been noted as either next to the hanging wall or near it in the upper half of the vein filling.

FIG. 14. View to the north along the strike of the Wildrose Canyon fault. The lava cap (B) on the top of the Benton Range granodiorite (Gr) is visible as a dark tree-covered patch to the left of the fault line, and as the dark ridge against the skyline to the right of the fault.

FIG. 15. View looking north showing the basalt flow (B) gently dipping to the east in contact with the granodiorite (Gr) beneath.

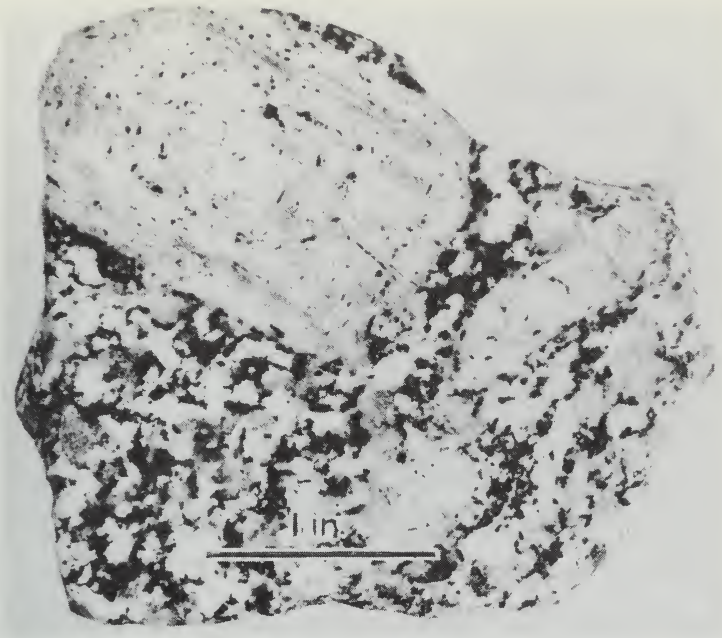


FIG. 16. Porphyritic granodiorite. This coarsely crystalline gray-colored rock is the most extensively occurring granitic intrusive in the area. The Benton Range is almost entirely granodiorite although the rocks are not always as porphyritic in character as this specimen from the west slope of Blind Spring Hill. The large phenocryst is orthoclase about 2 inches in length; inclusions of hornblende and biotite show the zonal growth of the crystal.

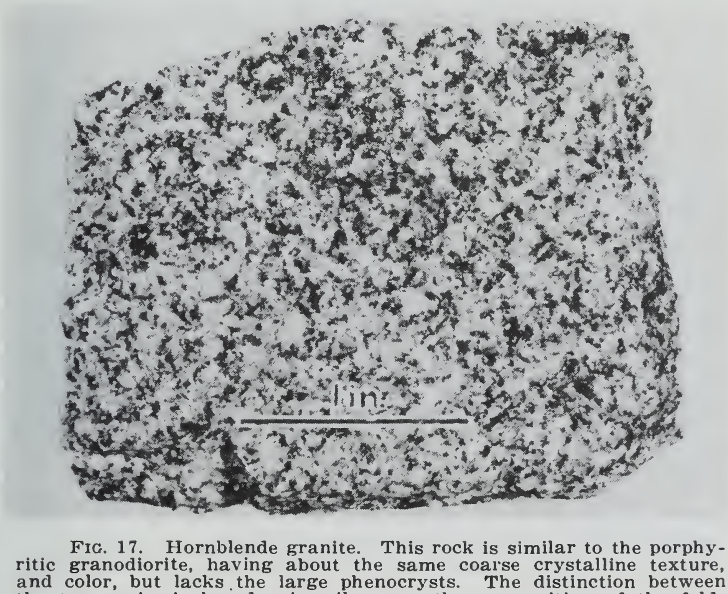


FIG. 17. Hornblende granite. This rock is similar to the porphyritic granodiorite, having about the same coarse crystalline texture, and color, but lacks the large phenocrysts. The distinction between the two rocks is based primarily upon the composition of the feldspars. Blind Spring Hill is largely made up of this type of rock.

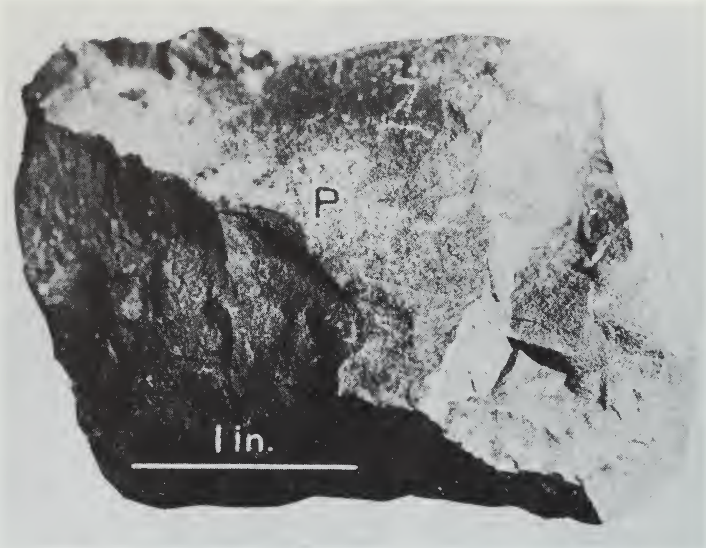


FIG. 18. Lamprophyre (?). Very fine-grained rock of a gray-black color occurring as dikes in the mineralized zone of Blind Spring Hill. A thin veneer of finely crystalline pyrite (P) occurs abundantly in the irregular fracture planes of the rock.

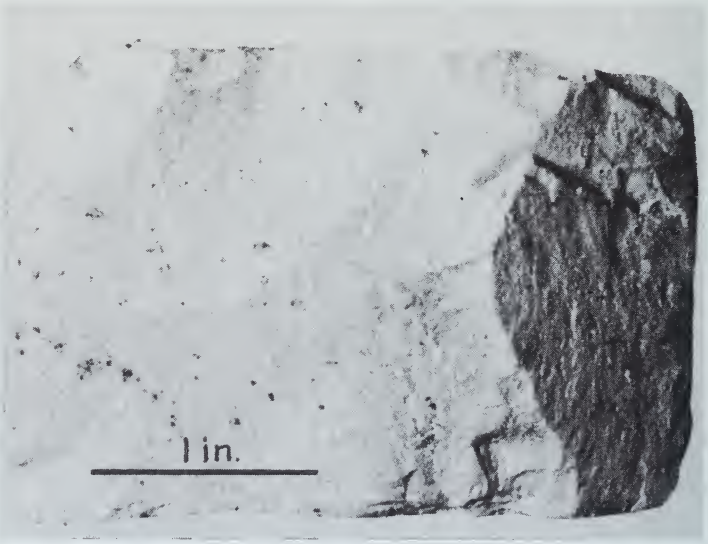


FIG. 19. Aplite. Very fine-grained rock of a gray-white color occurring as dikes in the mineralized zone of Blind Spring Hill. Small specks of pyrite can be seen throughout the rock.

FIG. 20. Basic dike rock. This rock occurring as dikes on Blind Spring Hill was difficult to classify. Greenish-gray in color, it is fine-grained, and is characterized by the presence of numerous round greenish spots which are composed of a mass of needle-like crystals, probably tremolite. Small patches of pyrite, often associated with the green spots, can be readily seen with the eye.

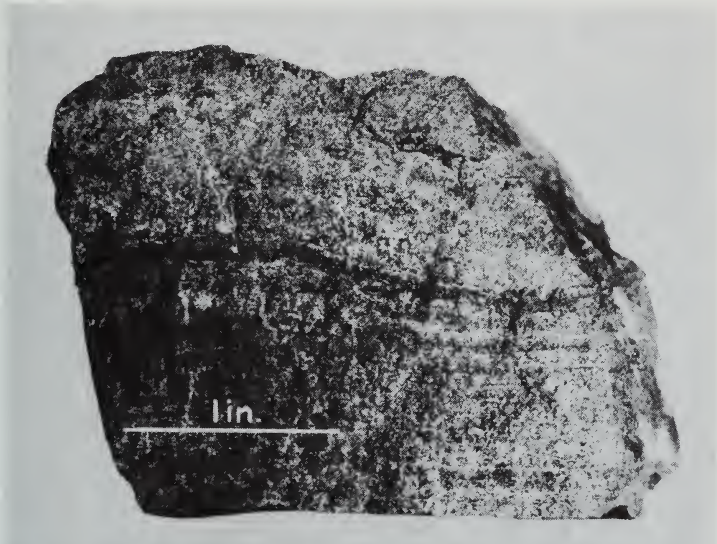


FIG. 21. Metamorphic rock. This particular specimen was obtained from a large outcrop called Garnet Hill east of Yellowjacket Spring near the road. Although almost completely garnetized, the bedding planes of the original sedimentary rock can be easily seen. Other patches of metamorphic sedimentaries in the southern part of the mapped area range in character from schist to almost a gneiss. Frequently this type of rock has been termed tactite.

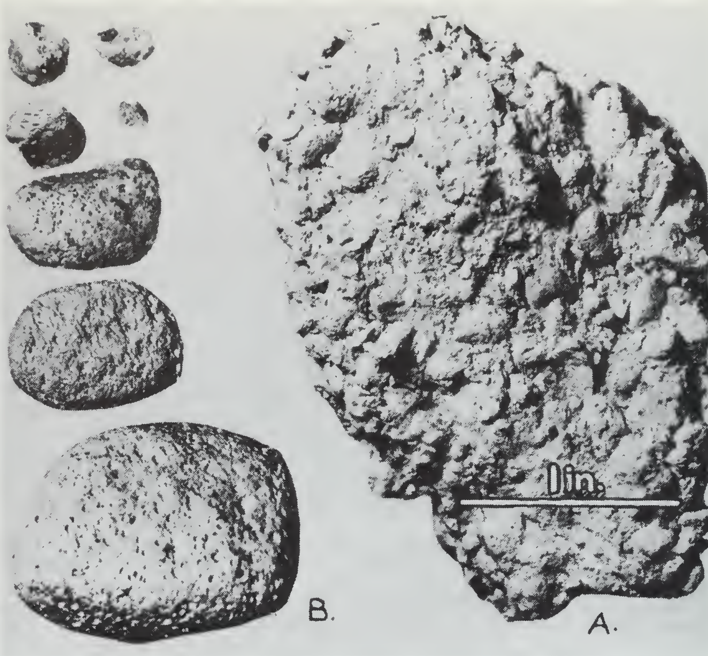


FIG. 22. A. Small round pebbles of pumice, very loosely cemented by a groundmass of volcanic glass dust. Obtained from a cliff exposure about one mile south of Yellowjacket Spring. B. Group of pumice pebbles from different beds in same outcrop as A, showing gradation in size from nearly 2 inches to about $\frac{1}{8}$ inch.

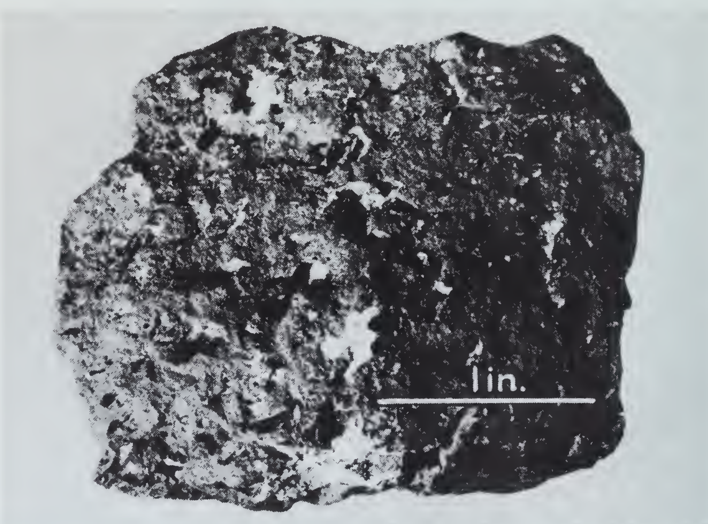


FIG. 23. Olivine basalt. This specimen was obtained from near the top of the flow and is vesicular. The white material is calcite filling in the cavities.

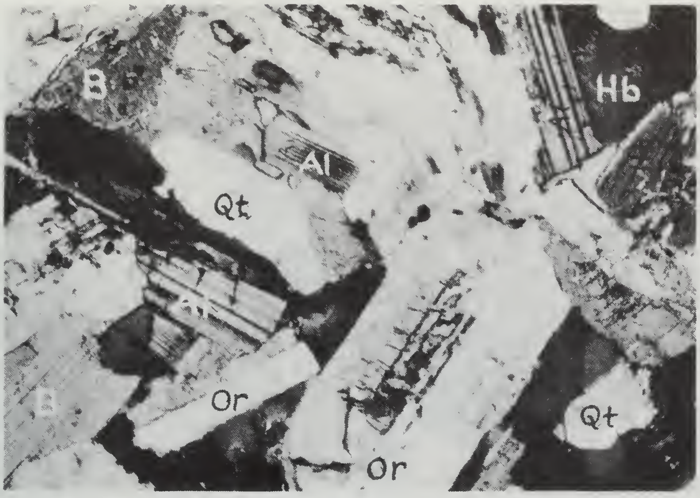


FIG. 24. Photomicrograph of hornblende granite. The nicols are crossed to show the texture of the constituent minerals; biotite (B), hornblende (Hb), albite and oligoclase (Al), orthoclase (Or), and quartz (Qt). Some apatite and titanite is present in small amounts. Magnification 80x.

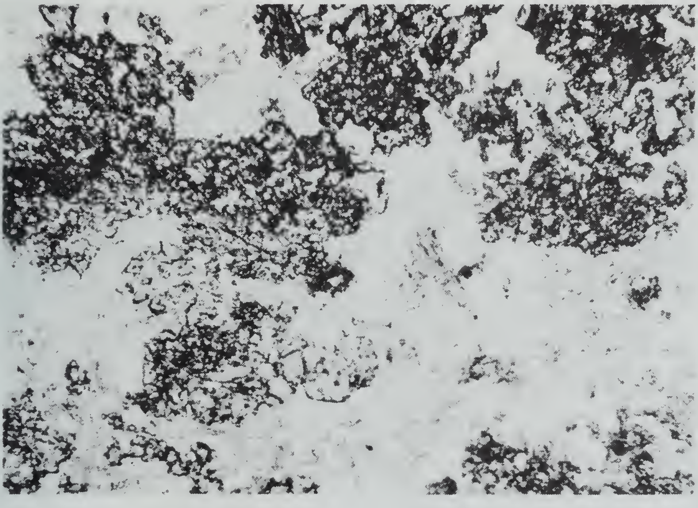


FIG. 25. Metamorphic rock from Garnet Hill near Yellowjacket Spring. The texture of this rock is very fine-grained and probably of sedimentary origin although mineral identification is difficult. Garnet, shown as dark patches with high relief, has replaced nearly the entire rock. Magnification 80x.

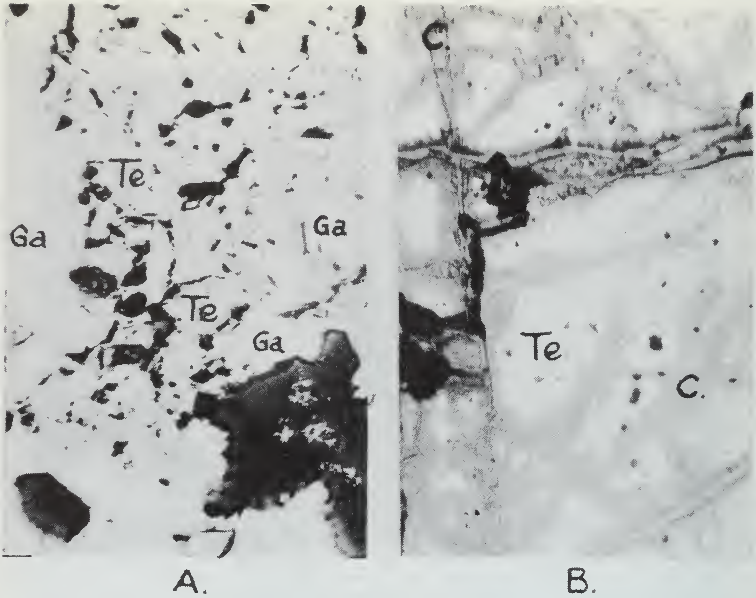


FIG. 26A. Galena (Ga) with tetrahedrite (Te). This specimen is from the lower levels of the Kerrick workings, and consists of rather thin stringy veinlets of galena in siderite and quartz. The galena is massive; and, as the photograph shows, has included with it massive tetrahedrite which occurs in patches. There is no evidence of replacement. Magnification 40x.

FIG. 26B. Tetrahedrite (Te) showing the "chemical brecciation" due to alteration along cracks and cleavage surfaces. This alteration of the primary sulphide, tetrahedrite, into secondary chalcocite and covellite (C) which forms the veinlets, is typical supergene enrichment of copper. A small amount of silver is present in the tetrahedrite. Magnification 40x.

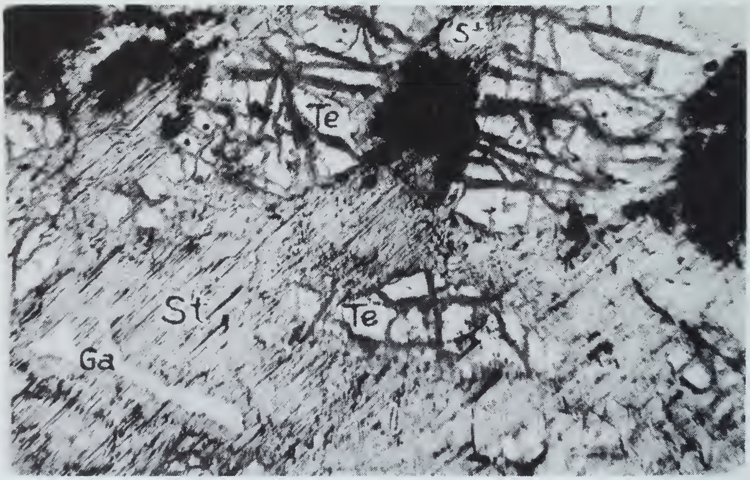


FIG. 27. Stromeyerite (St), tetrahedrite (Te), and galena (Ga). This is the so-called "black metal" the rich silver-bearing ore of the district. The stromeyerite $(Ag,Cu)_2S$, is the silver mineral which has formed by replacement of the tetrahedrite and galena, the latter being almost completely replaced. In all the specimens examined, the stromeyerite is found replacing tetrahedrite to a greater extent whenever galena is present. Some patches of the stromeyerite show the typical cubical cleavage of the replaced galena. Magnification 40x.

Tetrahedrite. This complex copper sulphantimonite is the principal primary copper mineral of the district, and from all evidences is the primary source of silver. Microchemical tests showed that the percentage of silver is too low to call the mineral freibergite, the rich silver-bearing variety of tetrahedrite. The mineral occurs in massive form, no crystals having been observed. Specimens from the deepest working show the tetrahedrite included in the primary galena with no alteration of either mineral. In the oxidized zone the mineral becomes more common, showing the ''chemical brecciation'' with the veinlets of alteration minerals running through it. Associated with it are the primary minerals galena, pyrite, chalcopyrite, and some sphalerite; and the secondary alteration minerals chalcocite, covellite, stromeyerite, malachite, and some azurite. Occasional native silver is also found in the upper oxidized zone, along with remnants of the tetrahedrite that has been almost completely altered.

Stephanite and *Pyrargyrite.* Both of these silver sulfantimonites have been reported as occurring, but were not recognized in any specimens examined.

Cerargyrite. This chloride of silver has been reported as being one of the ore minerals on the hill in the upper oxidized zone. Examination of specimens of the oxidized ore, especially crusts of cerussite with galena that carry values in silver, indicate the presence of a possible silver mineral which may be cerargyrite.

Massicot. In the upper oxidized zone, an earthy yellowish material resulting from the alteration of the lead minerals is quite commonly found associated with anglesite and cerussite, enclosing a galena core. It varies from a dusty bright yellow coating through dull, waxy, brownish yellow masses mixed throughout the crusty cerussite. Attempts to isolate any one mineral were unsuccessful, and it is very likely that the material is a mixture of several of the alteration products of lead including the lead monoxide, massicot; the complex hydrous antimonate of lead, bindheimite; some of the arsenate of lead, mimetite; and other lead compounds.

Specularite. The micaceous or specular variety of hematite was found in one spot in the siliceous outcrop of the Cornucopia vein.

Quartz. The most common gangue mineral in the district, quartz, is the chief constituent of the mineralized portion of the veins. Generally the color is white and cloudy in appearance, although clear quartz in the veins is common, it is often of a blackish color due to the presence of limonite. The general appearance of the quartz is massive, although there are many small cavities showing crystals. In the Hudson adit several vugs were found in the vein containing a few crystals of clear quartz of from one to three inches in length. In the lower oxidized zone, pyrite is the chief associate mineral, which alters to limotite toward the surface. In nearly all cases where ore is found, the mineralization is on one side of the other, and in close contact with a thinned out portion of the quartz vein. Often the quartz locally pinches out.

Limonite. This hydrous oxide of iron is found most abundantly in the oxidized superficial parts of the veins occurring principally in the quartz. The color is usually black, but shows a brownish powder on scratching. It is also quite hard. Occasional patches of the soft yellow, powdery, ocherous variety occur with the ore minerals, but is unusual with the quartz.

"Copper pitch." This rather peculiar copper-containing substance occurs among the products of oxidation in the upper workings. The color varies from a deep olive-green through dark brown to black. Sometimes it is dull, but generally has a glassy to resinous luster. The hardness varies from about 4 to 5. It is associated with some azurite, malachite, and chrysocolla, as well as limonite. Often it encloses these minerals, usually with apparent gradation and especially with the chrysocolla. Analysis of copper pitch ores from other localities shows a high percentage of copper. The nature of the substance is not definitely known, some investigators having described it as impure chrysocolla, a mixture of various minerals, and a definite mineral. The latest work has been done by Guild,[1] who considers the substance as being a mixture of several hydrous oxides.

Cerussite. This carbonate of lead is an alteration product of the galena and is quite common in the near surface workings of the veins which are rich in galena.

Malachite. The basic carbonate of copper, malachite, is very common in the district. There are small veinlets running through the "chemically brecciated" tetrahedrite, and large masses in the veins have been found in the oxidized zone. It carries some silver.

Azurite. This basic carbonate of copper, in contrast to the malachite, is rather rare in the district, occurring in small amounts, primarily as little veinlets running through the tetrahedrite associated with the malachite. Some small vugs filled with minute crystals were found.

Siderite. This iron carbonate is second to quartz in volume as a gangue mineral, and occurs in greatest amount in the lower levels where the quartz has thinned out to a large extent. The principal associate mineral is pyrite, usually occurring as small cubical crystals inbedded in the siderite. Galena, including tetrahedrite, also occurs as veinlets running through the siderite gangue.

Calcite. This usually common mineral is not much in evidence in the district in connection with the ores and the most prominent locality where calcite was found, although in small quantity, was on Garnet Hill in the contact zone south of Blind Spring Hill near Yellowjacket Spring.

Chrysocolla. Throughout the oxidized zone small veinlets and occasional crusts of the hydrous copper silicate, chrysocolla, are found associated with malachite, azurite, and copper pitch. It was never found in large masses or great amounts. Though seemingly amorphous, the microscope reveals it to be finely crystalline.

[1] Guild, F., Copper Pitch Ore.: American Mineralogist, p. 313, 1929.

Cornuite. This is an amorphous copper silicate, corresponding to crystalline chrysocolla, and is found associated with the crystalline variety.

Dioptase (?). A few small clusters of emerald green crystals of what is thought to be the silicate of copper, dioptase, were found on a large specimen which was taken from the Cornucopia mine. Dioptase is a rather rare mineral having been found at only a few localities, and seldom in the United States. The crystals observed were lining small cavities in malachite. The color, emerald green, is markedly different from the typical green of malachite; and the crystals which measured approximately 1-2 mm. in diameter are of the requisite form for dioptase. Inasmuch as the only specimen showing these crystals belonged to private collection, (on display in the Benton Post Office) no samples were obtainable upon which accurate tests could be carried out to prove definitely that the mineral was dioptase.

Garnet. No garnet occurs with the ores; in fact, none was found on Blind Spring Hill, but near Yellowjacket Spring an entire hillside of garnetized rock outcrops prominently. Most of the mineral occurs so finely crystalline as to appear massive; but along fracture planes and lining cavities, were found many small crystals ranging up to several millimeters in size. The color varies from an olive green in the massive form to a greenish brown in the more crystalline variety. The garnet was formed through contact metamorphism.

Epidote. This mineral occurs in small amounts associated with the above mentioned garnet. Occasional small patches were found in the granitic rocks close to the intrusive dikes on Blind Spring Hill. One specimen of rather large crystals about one-half inch long, imbedded in quartz, was found as float on top of the hill. The source was not located.

Pyromorphite. A few minute crystals of the lead chloride-phosphate mineral, pyromorphite, were found lining the bottom of a cavity on a specimen obtained from the hill, the exact locality of which is not known. The crystals measure only a fraction of a millimeter in diameter, and are hexagonal, and prismatic in habit. The color is light green, the luster adamantine, and microchemical tests prove the presence of lead. The nature of the mineral would indicate its occurrence in the upper portions of shoots of lead ore, probably quite near the surface.

Mimetite. In the upper portions of the veins rich in galena, the arsenate of lead, mimetite, is probably present as an alteration mineral in association with cerussite, mixed with massicot and bindheimite.

Bindheimite. The oxidation of the galena-tetrahedrite ores yields among other things an amorphous greenish or olive yellow material which is resinous, soft, and sometimes powdery. This is described under the mineral massicot, and is probably a mixture of several lead alteration products. The addition of antimony from the alteration of tetrahedrite would naturally lead one to suspect that the hydrous antimonate of lead, bindheimite, would be present.

Anglesite. The sulphate of lead occurs widely in moderate quantities in the zone of oxidation as the first product of the alteration of galena. It has been found mixed with the cerussite near the surface, and as concentric bands around a central core of galena. Several specimens from different workings have shown this last effect, which seems to be generally confined to the peculiar massive laminated variety of galena previously described.

Wulfenite. Small yellow-orange tetragonal crystals of lead molybdate measuring less than one millimeter in diameter were found on top of the previously described pyromorphite in a small cavity. This is the only known occurrence.

Partzite. According to story this silver-bearing substance was named after a German assayer, Partz, who worked in the district in the early days. It was found almost entirely in the upper workings near the surface, and was considered the highest grade silver-bearing ore on the hill other than the "black metal." It was first described by Arents in 1867.[1] He describes partzite as a mineral, classifying it as a hydrous oxide of antimony. His chemical analysis is as follows:

Sb_2O_3	Cu_2O	Ag_2O	PbO	FeO	H_2O
47.65%	32.11%	6.12%	2.01%	2.33%	8.29%

Its occurrence, he states, was in the upper oxidized zone in blackish green to black masses.

Later in the same year, Blake[2] wrote a discussion of Arents' article, in which he stated that the mineral partzite was not a definite mineral, but a mixture of several minerals or substances of varying composition.

A great deal of unsuccessful effort was made to obtain some specimens of the original partzite. Several pieces of what were said to be partzite were obtained from various sources and examined, but no two were alike; and microchemical tests on what seemed to be the best material showed the presence of a large amount of copper and lead, the possibility of some iron, but little else. Tests for antimony were unsuccessful, and the presence of silver was doubtful, certainly not to the reputed extent of the richness credited to it.

The polished surface of the so-called partzite showed a definite mixture of mostly oxidized minerals. The positive determination of these was not attempted because of the doubt of its representing the material originally described as partzite.

OCCURRENCE OF THE ORES

Zone of Mineralization

The zone of mineralization on Blind Spring Hill occupies an area about two miles long in a north-south direction in about the center of the hill; and practically traverses the hill from one side to the other in an east-west direction. The richest mineralized portion, from which the greatest amount of ore has been taken from the most extensive

[1] Arents, A., Amer. Jour. Sci., Vol. 93, p. 362. 1867.

[2] Blake, W. P., Amer. Jour. Sci., Vol. 94, p. 119. 1867.

mines, covers an area of about one square mile in about the center and towards the southern boundary of the zone described above. The best picture of this general distribution is obtained by referring to the outlined patented property of the Comanche Company as shown on the vein system map.

The deposits may be characterized as lead, copper, and silver ores, with a small amount of gold not of commercial importance, and a number of alteration minerals. The lead occurs in the upper portions as carbonates, oxides, and some sulphide and sulphate, the latter increasing with depth. Copper appears chiefly as carbonates in the upper levels and at depth to a certain extent, but occurs mainly as tetrahedrite from the intermediate levels to depth with a certain amount of chalcopyrite. Silver, the sought after and valuable metal in the district, appears to have originated in the tetrahedrite; but is chiefly found as a secondary mineral, stromeyerite, associated with the tetrahedrite and galena.

In general the silver has proved to have been richest in the oxidized zone down to about 800 ft. The lowest section to be mined has shown rich lenses of ore; but the general trend with increased depth has been less silver and more copper with persistence of lead.

The ore deposits of the Hill occur in filled fissure type of veins. The hanging-wall and the foot-wall both show slickensides wherever examined, indicating movement, the major portion of which occurred before mineralization took place. The character of the vein minerals, especially that of the quartz, is indicative of this type of vein. There are numberless small cavities and vugs which contain well defined crystals that would hardly be formed in other than an open fissure, which would allow crystal growth.

The veins do not outcrop prominently on the hill. The vein material is generally softer than the surrounding granitic rocks, and is therefore easily eroded. There are some quartz stringers that appear on the surface, but at the present time there are few outcrops left on the hill. The very apparent answer to this is that wherever a former outcrop showed on the surface, it was promptly dug out by prospectors. The hillsides are literally pockmarked with such pits, trenches, and shallow workings of all kinds. In fact, the best way to follow the vein is to follow the diggings.

The general color of the silicified vein matter in these holes which represent the croppings is brown, as compared to the gray color of the surrounding rock. The quartz, whenever present, is generally milky, dull, and massive with the exception of the everpresent small cavities and vugs enclosing some crystals. There is usually a yellow-brown stain throughout the cracks and occasional pockmarks, that proves to be limonite from the original pyrite and other iron-bearing minerals.

STRUCTURAL CONTROL

Vein Systems

The main ore-bearing veins form a system of fissures in the granitic rocks of the Hill which strike from N. 10° W. to N. 20° W. The dips of the different veins vary from 40° to 45° east, with the exception of the Comanche vein which has a varying dip of about 80° east. With a possible one or two exceptions, there is no branching of the veins, the

only structural feature being a tendency towards a local flattening of the dip in places. This younger set of veins is remarkable because of the almost parallel arrangement of the fissures with no intersections.

A second series of parallel post mineral older fault fissures, striking east-west across the Hill, cuts the first series of veins causing some normal faulting. This older series of fissures has shown no evidence of carrying any mineralization of silver or gold and, although extensively prospected, has proved to be barren of anything other than quartz and iron oxide.

Relation to Wall Rock

In all cases where the veins were observed underground, both the hanging-wall and the foot-wall were in sharp definite contact with the vein. In practically every case this contact showed movement, slickensides being very much in evidence. By the vein is meant not only the mineralized portion of the quartz alone, but the remaining vein filling and fault gouge, whenever they are present. The walls are generally bounded by the crystalline granitic rocks, with the exceptional type that has one granitic wall, and one wall of dike rock.

Persistence of Veins

In general the fractures and fissures in this area are strong, well defined, and persistent, at least down as far as the present level of mining has progressed which is from 900 to 1100 ft. vertically. The average width of the veins is approximately 3 to 4 ft., with a minimum of less than a foot to a maximum of 6 to 7 ft. The mineralized portion of these veins has a width from 3 inches to about 2 ft., usually occurring in the upper half of the vein or next to the hanging-wall.

The ore bodies in these veins occur as irregular lenses which have a general pitch to the south with a varying length of from 20 to 100 ft. It has also been noticed during development work on the Diana-Kerrick vein, that wherever there is a flattening of the dip the vein increases in width with a richer concentration of ore.

In the lower levels of the Kerrick workings, the primary sulphides are in greater evidence with assays showing less silver and more copper and lead. The veins are still persistent, but with noticeable decrease in mineralization.

It was reported that the transportation tunnel which was driven through to the Kerrick workings on the 5400-ft. contour level, about 1200 ft. below the crest of the Hill, had cut the veins with no showing of ore mineralization until it reached the Diana-Kerrick vein.

Effect of Faulting

The inaccessibility of most of the underground workings prevented any examination being made for the purpose of studying in detail the effects of faulting on the veins. The Hill is cut by many small faults with movements of only a few feet more or less, and the survey of the main level of the Cornucopia Mine shows a few of these that were encountered.

The post mineral series of parallel faults, many of which are prominent by the presence of lamprophyric dikes, the last stage of

intrusion, run in an east-west direction across the Hill and have a generally steep dip toward the north. These faults are the only ones that have had any apparent effect on the vein systems, causing mostly normal faulting with a displacement of the veins of from about 30 ft. or less to from 100 to 150 in what was described as the Comanche fault, by Mr. Pernot.[1] Only rarely has such faulting hindered location of the displaced segment of the veins.

HYPOGENE AND SUPERGENE MINERALIZATION

Alteration by hot water ascending through the cracks and fissures has not penetrated the wall rock more than a foot or so at most, where observations were made. Some sericitization near the veins has taken place; but the greatest amount of such alteration, especially silicification, is to be found in the so-called ''porphyritic fissure filling'' (apart from the actual mineralized vein material). The walls on both sides of the vein are generally well defined and clean cut.

Pyritization has generally affected the entire mineralized area. Pyrite is perhaps the most common mineral in and around the veins, in siderite gangue, and is found in all the various types of intrusive rocks on the hill, including dikes. Some of it is no doubt primary, but the greater portion is associated with the ferromagnesian minerals from which it has formed.

The alteration of the hypogene minerals by surface waters is considered apart from metamorphism, and as such will be briefly described here as a recent stage in the formation of the ores. The zone of oxidation reaches a maximum depth of about 800 ft. below the outcrop of the Kerrick vein, and probably averages from 600 to 700 ft. throughout the hill.

Level of the ground water: There are no records of the depths at which water was encountered in the mines, and no first hand knowledge could be secured because of inability to examine the deeper workings, the upper accessible case being invariably dry. However, there is a small stream of water which constantly flows out from the transportation tunnel at the 5400-ft. contour level. This would place the present water level at between 1000 and 1200 ft. below the average surface of the hill at its crest. No doubt the level of the ground water before mining took place approximated the outline of the oxidized zone at an average depth of from 600 to 800 feet below the surface of the hill.

Extent and character of the alteration: It is unfortunate that a complete examination could not be made along a vertical range from the surface to the bottom of the present deepest workings, in order to give an accurate picture of the alteration. However, certain facts can be given from examination of accessible (near the surface) workings and from specimens known to have been taken from the lower levels.

The oxidized zone does not indicate that complete oxidation has taken place; but that minerals formed through oxidation and the presence of aqueous solutions are present down to the 600 to 800 ft. level below the surface, but not to the exclusion of the primary sulphides. Galena, one of the two most prevalent primary sulphides,

[1] Pernot, P. H., Private Report on Commanche Mine. 1920.

occurs in the veins within a few feet of the surface and even in the outcrops. In the oxidation zone, the galena is frequently found as a core in the center of encrusted anglesite and cerussite. Some of the galena-tetrahedrite ore has been altered to an earthy yellow mineral, an antimonate of lead—probably bindheimite. In general, the oxidation decreases with depth, occurring along the edges of the galena and in the cleavage cracks.

The outstanding primary copper mineral, tetrahedrite, shows chemical brecciation at considerable depth. This alteration, producing a brecciated appearance under the microscope, is the change along fracture and cleavage planes of the primary tetrahedrite into veinlets of chalcocite, covellite; then further alteration into malachite, and occasional azurite. Specimens from the lowest levels show no change or alteration of either the galena or the tetrahedrite.

The primary lead ore (galena) alters to anglesite and this to cerussite. Further alteration results in a brownish-yellow, waxy amorphous mineral, which eventually passes into a dusty bright yellow material. This appears to be a mixture of lead oxide, probably massicot, and other complex alteration products, chief of which may be bindheimite, a compound of lead and antimony derived from both the galena and the tetrahedrite. Some of the oxidized material carries cerargyrite, the chloride of silver. The primary copper ore, tetrahedrite (a complex sulfantimonite of copper) alters to chalcocite (the chalcocite partially altering to covellite) and then to stromeyerite, the latter alteration taking place to a large extent in the presence of galena. This mixture of tetrahedrite, galena, chalcocite, covellite, and stromeyerite is what is known as "black metal," and carries the high silver content. Further alteration seems to produce a material called "partzite," which upon examination proves to be a mixture of unidentifiable minerals reputedly rich in silver. Occasional small specks of native silver, probably from the stromeyerite, have been found in the upper oxidized zone along with "partzite."

Silver was not recognized in the primary sulphide form, and seems to occur only as described above. It was determined by microchemical tests that the tetrahedrite is evidently the primary source for the silver, as it carries small amounts of that metal. The galena that showed silver content proved upon examination to be enclosing a large amount of the silver-bearing tetrahedrite.

GENESIS OF THE ORES

Generally speaking, the ore deposits occur in a system of parallel fault fissures that traverse an intrusive stock made up of several types of crystalline granitic rocks, varying in composition from acid to basic. These fault fissures are entirely in the intrusive rock and continue down to unknown depth. It is reasonable to assume that the ascending solutions carrying ore minerals into the fissures are genetically connected with the intrusive rocks of the hill.

The presence of aplitic dikes, which include primary sulphides, galena, and pyrite, the same as are found in the ores, seems to indicate in addition to the structural evidence of proximity and close association, that the mineralizing solutions were contemporaneous with or immediately followed the intrusion of the aplite dikes—both coming from the

same source, a cooling magma at depth, in the last stages of crystallization.

In certain of the fault fissures, in the already cooled and congealed upper portion of the stock between walls of the crystalline granitic type of rocks, ores of lead and copper, including some silver, were formed. The excess of quartz and pyrite and the silicification of the vein filling, as well as the extent of pyritization throughout the mineralized area, point to the action of hot, probably alkaline aqueous solutions, such as would be expected to rise from an igneous magma.

These hot aqueous solutions rising from the deep-lying, still molten portion of the magma transported ore-making elements outward toward the surface, depositing them when the requisite temperatures and pressures were obtained. The resulting hypogene or primary minerals were galena, chalcopyrite. and tetrahedrite, the latter containing the silver. The type of mineralization indicates that the deposits were formed at moderate depth, at temperatures of from 200 to 300 degrees Centigrade. The present outcrops are exposed by a combination of faulting with deep erosion. This would be considered a mesothermal deposit, according to the classification of Lindgren.[1]

The primary ores themselves do not contain a high percentage of silver. The deposits that are rich in silver were formed through a process of supergene sulphide enrichment. The circulation of surface waters downward was the essential medium for chemical action which resulted in the oxidation and alteration of the primary minerals into complex associations of oxides, sulphates, and sulphides. In this way the rich silver-bearing secondary mineral, stromeyerite, was formed by replacement of tetrahedrite and galena. The silver in the tetrahedrite, and possibly some from galena, was chemically enriched and formed the combination known as ''black metal.''

EPOCH OF MINERALIZATION

The epoch of metallization in the Blind Spring Hill district occurred after the intrusion of the stock. Ore mineralization on the Hill took place subsequent to the formation of the principal fissure system and this is closely allied with the intrusive aplite dikes; the lamprophyric intrusions are evidently post mineral. As the intrusion of the stock probably occurred in the Jurassic, the ore-forming epoch which followed shortly can be best dated as late Mesozoic.

[1] Lindgren, W., Mineral Deposits, page 212.

SPECIAL ARTICLES

Detailed technical reports on special subjects, the result of research work or extended field investigations, will continue to be issued as separate bulletins by the Bureau, as has been the custom in the past.

Shorter and less elaborate technical papers and articles by members of the staff and others are published in each number of CALIFORNIA JOURNAL OF MINES AND GEOLOGY.

These special articles cover a wide range of subjects both of historical and current interest; descriptions of new processes, or metallurgical and industrial plants, new mineral occurrences, and interesting geological formations, as well as articles intended to supply practical and timely information on the problems of the prospector and miner, such as the text of new laws and official regulations and notices affecting the mineral industry.

SHORT REPORT ON THE GEOLOGICAL FORMATIONS ENCOUNTERED IN DRIVING THE MONO CRATERS TUNNEL

GENERAL INFORMATION ON THE MONO CRATERS TUNNEL

Compiled by W. K. Gresswell [1]

The Mono Basin Project is being constructed by the Los Angeles Bureau of Water Works and Supply for the purpose of increasing the water supply of Los Angeles by approximately 145 c.f.s. The main feature of the project is the Mono Craters Tunnel which pierces the Mono Craters and the high mesa lying between Mono Basin and Long Valley; the tunnel is to convey water from the Mono Basin watersheds to the Owens River.

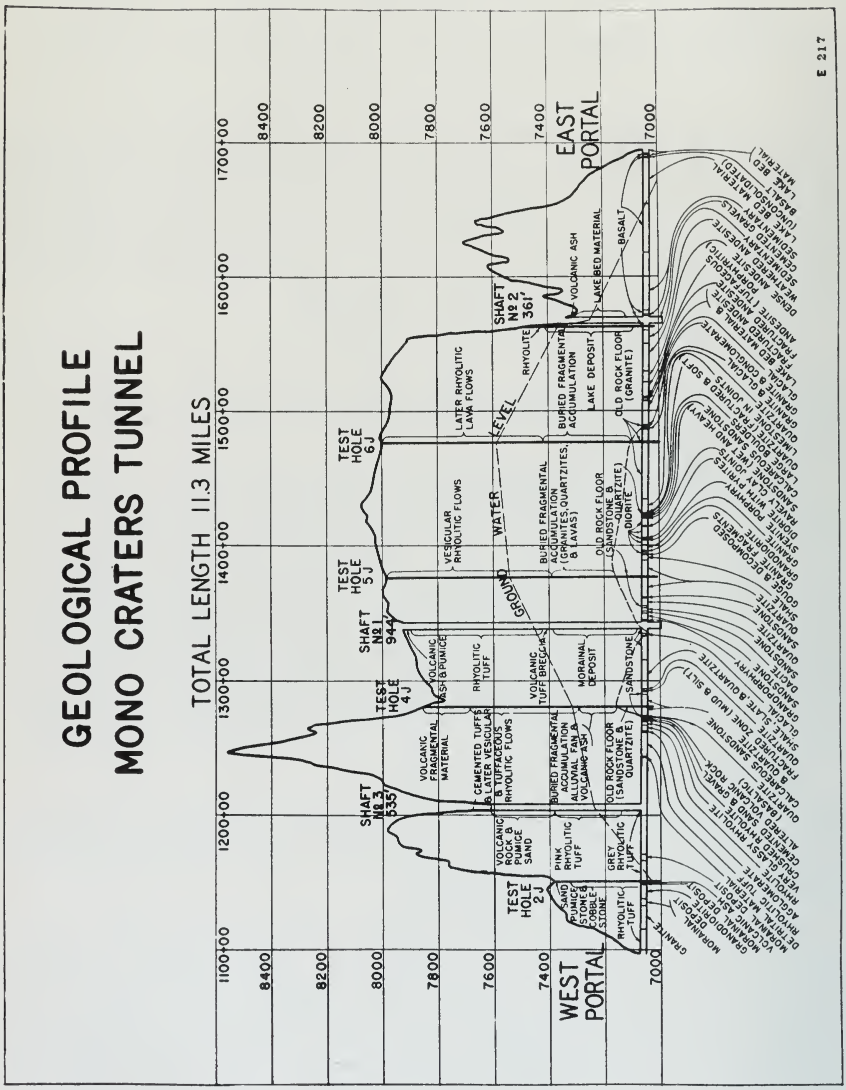
West Portal, at an elevation of 7,058 feet is located 7.8 miles southeast from the town of Leevining in Mono Basin. From this point, the tunnel runs south $55\frac{2}{3}°$ east for 42,825 feet to an angle point, thence south $43\frac{1}{3}°$ east for 16,987 feet to East Portal—a total distance of 59,812 feet.

Excavation of the tunnel was carried on from six headings. Heading No. 1 was driven 22,426 feet easterly from West Portal. From Shaft No. 1, which is 944 feet deep and 24,462 feet easterly from West Portal, Heading No. 2 was driven 2,036 feet westerly and Heading No. 3, 7,837 easterly. From Shaft No. 2, which is 361 feet deep and 12,735 feet from East Portal, Heading No. 4 was advanced 14,778 feet westerly and Heading No. 5, 2,808 feet easterly. Heading No. 6 was driven 9,927 feet westerly from East Portal. Shaft No. 3, 535 feet deep and 10,937 feet from West Portal, was constructed for the purpose of providing additional and much needed ventilation and dewatering facilities for Heading No. 1.

The large amounts of water and carbon dioxide gas discharged into the tunnel from the formations driven through made construction of the tunnel very difficult. The maximum water flow from all headings was approximately 20,000 gal/m or 44 c.f.s.; of this 9,300 gal/m was pumped from Heading No. 1 alone.

The gas zone extended from a point 7,800 feet from West Portal to 19,500 feet, or a distance of 11,700 feet. The quantity of carbon dioxide made in this zone averaged approximately 1,000 cf/m with the maximum approaching 1,400 cf/m. Usually about 40% of the gas made in the tunnel remained in the water, with 60% being liberated into the air. It was necessary to force 30,000 cubic feet of air per minute into the tunnel to keep the CO_2 content of the tunnel air below $2\frac{1}{2}\%$.

[1] Compiled from papers by H. L. Jacques—"Mono Craters Tunnel Construction Problems," *Journal of the American Water Works Association,* Vol. 32, No. 1, January, 1940, and W. W. Wycoff—"Mono Craters Tunneling Has Involved Struggle with Water and Gas Flows," *Western Construction News,* Vol. XIII, No. 12, December, 1938.


GEOLOGICAL PROFILE
MONO CRATERS TUNNEL
TOTAL LENGTH 11.3 MILES
WEST PORTAL
EAST PORTAL
TEST HOLE 2J
SHAFT Nº 3 535'
TEST HOLE 4J
SHAFT Nº 1 944'
TEST HOLE 5J
TEST HOLE 6J
SHAFT Nº 2 361'
GROUND WATER LEVEL
1100+00
1200+00
1300+00
1400+00
1500+00
1600+00
1700+00
8400
8200
8000
7800
7600
7400
7000
VOLCANIC FRAGMENTAL MATERIAL
CEMENTED TUFFS & LATER VESICULAR & TUFFACEOUS RHYOLITIC FLOWS
VOLCANIC ASH & PUMICE
RHYOLITIC TUFF
VOLCANIC TUFF BRECCIA
MORAINAL DEPOSIT
SANDSTONE
VESICULAR RHYOLITIC FLOWS
LATER RHYOLITIC LAVA FLOWS
RHYOLITE
VOLCANIC ASH
LAKE BED MATERIAL
BASALT
LAKE DEPOSIT
OLD ROCK FLOOR (GRANITE)
DIORITE
E 217

Geological Formations

Shafts

Formations encountered in sinking Shaft No. 1 were as follows: 18 feet of loose volcanic ash, 507 feet of fairly hard rhyolitic tuff, 38 feet of volcanic ash, 308 feet of glacial gravels, and 73 feet of sandstone (old rock floor).

The first 525 feet of Shaft No. 1 was excavated with little difficulty and in good time. The ground water plane was intercepted at a depth of 492 feet from the collar, or 33 feet above the bottom of the hard rhyolite. Difficulties in sinking the shaft began upon entering the volcanic ash lying below the rhyolite. This ash was in all degrees of fineness and was difficult to hold as it would seep through the lagging or spiling or boil up from the floor, causing much cavitation back of the timbers. Difficulties in constructing the shaft increased as it was sunk into the glacial gravels. While large boulders, of such size as to require blasting, were often encountered, the greatest trouble was found in the fine sands and silts which would, due to the existing water pressures, boil up from the bottom of the shaft and fill it for many feet. Each run would relieve the pressure for a time but there was a tendency for the gravels immediately surrounding the shaft to be sealed up by the fines with a resulting diminished flow of water and increased pressure until another run-in would occur. The sandstone encountered at tunnel grade was soft, fractured and had a pronounced tendency to squeeze. This ground was very difficult to hold, and the shaft station at tunnel grade and the muck pocket were necessarily made smaller than had been planned.

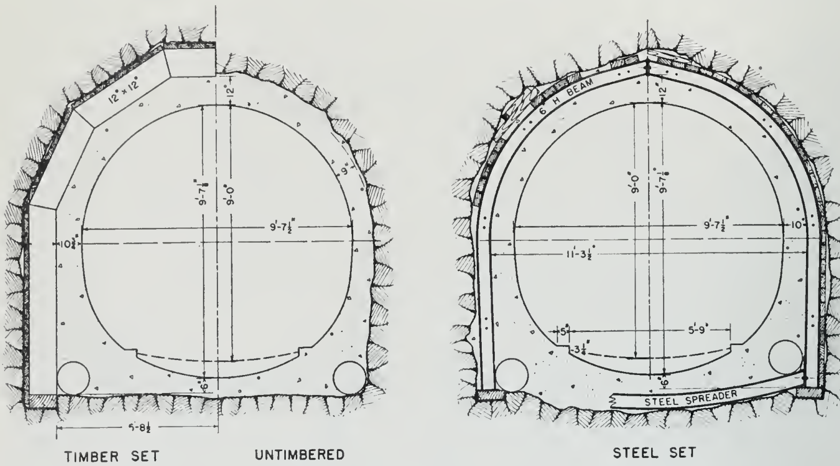
Shaft No. 2, presented no difficulties in sinking. The formations encountered in sinking this shaft were as follows: hard rhyolitic tuff at the collar, 7 feet of loosely cemented volcanic ash, 207 feet of streambed clayey gravel, 113 feet of basalt, and 34 feet of fairly well cemented glacial gravel. The hard basalt encountered at tunnel grade was excellent formation in which to excavate a spacious station to house necessary construction facilities.

Shaft No. 3 was sunk 208 feet in volcanic ash, the remainder of the shaft being constructed in rhyolite of various degrees of hardness. The rhyolitic formation struck at tunnel grade was excellent material in which to excavate a large pump station.

Tunnel

The formation encountered in driving the first 17,300 feet of Heading No. 1 was mostly rhyolite, although in the first mile the tunnel penetrated small spurs of granite with intervening valleys filled with glacial gravels, volcanic ash and detrital materials. The rhyolite was, as a whole, fairly hard and required occasionally only light support. The other formations in this part of the tunnel generally required support with tight lagging. Water was encountered at 6,100 feet, and carbon dioxide gas in small quantities was detected at 7,800 feet. As the tunnel was advanced both water and gas increased materially, until at 13,000 feet and again at 15,230 feet, it became necessary to suspend driving operations at the face until additional ventilation and dewatering facilities could be installed.

At 14,400 feet from West Portal, and for several hundred feet farther on, Heading No. 1 passed through a badly broken formation indicating a major fissure or fault, probably one through which the craters erupted. Fragments of granite and limestone were found in driving through this vent of one of the craters, indicating that the eruption must have penetrated upward through old granites and lime-



CROSS SECTIONS
MONO CRATERS TUNNEL

stones. Warm springs, up to 97° F., highly charged with carbon dioxide, were encountered. The badly fractured nature of the formation together with the large quantities of water and gas encountered in this area made it a very troublesome one to penetrate.

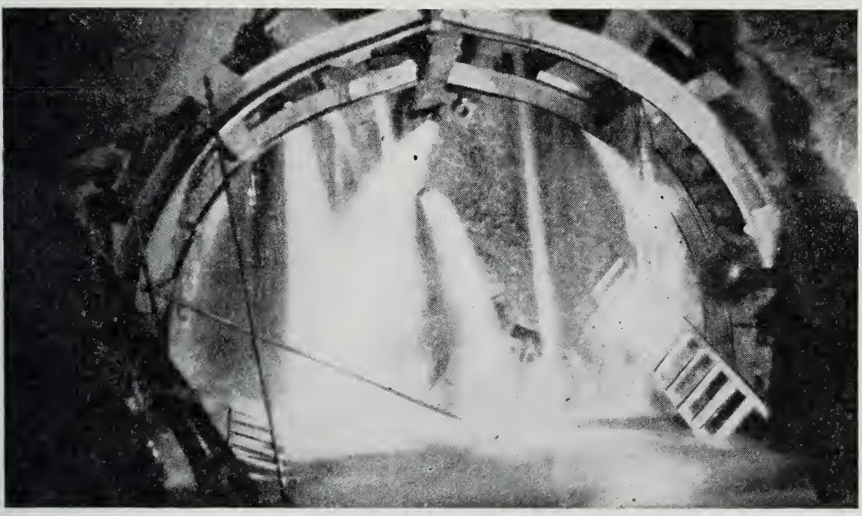
At 17,300 feet, Heading No. 1 passed through a transition zone of agglomerates consisting of debris from volcanic formations and underlying alluvial deposits and entered into the ancient rock floor; old metamorphics consisting of quartzites, sandstones, shales, and slates. For the most part, these old sedimentaries are thinly bedded and have been subjected to great disturbances resulting in much distortion, fracturing, and weathering. The bedding planes are usually found dipping at steep angles commonly toward the north. The strike is generally in an east and west direction. Their vertical attitude permits free percolation of water from the overlying alluvial and glacial gravels and other pervious formations. In the first 3,000 feet of the sedimentaries penetrated by Heading No. 1, the sandstones are calcareous and carbonates are generally found in the joints of the quartzites and shales. The sources of the carbon dioxide gas found in the tunnel are most likely these carbonates and calcareous formations which have been broken down by volcanism and the action of acids commonly found in active volcanoes.

The contact between the old rock floor and the overlying glacial gravels was followed by Heading No. 2 for approximately 800 feet west of Shaft No. 1, the heading going in and out of the sandstone and gravel formations many times in that distance. At every change in

formation, considerable additional water was brought in and this, together with the highly weathered condition of the sandstone and the unstable condition of the gravels, made tunnel driving extremely difficult and dangerous.

Heading No. 3 was driven wholly through metamorphics: quartzites alternating with thinly bedded sandy shales predominating. Through this section numerous intrusions of granitic rocks (diorites, porphyries and related rocks) were encountered. Each contact was accompanied by much faulting and weathering with the feldspathic minerals in the rocks in many instances highly kaolinized, causing the ground to squeeze from the sides and arch and raising of the floor. The core of some of the intrusives, especially the diorites, was often very hard, sometimes requiring 60 per cent powder to break the rock. It also broke very blocky, making mucking slow and often requiring secondary shooting.

The ground within the metamorphic zone which extended for three and one half miles of the tunnel (starting in Heading No. 1 and ending in Heading No. 4) was most variable in character, changing from hard to soft or vice-versa within a few feet and was very heavy, requiring extra strong support throughout. Fissures filled with loose sand, silts and clays, and accompanied by water, were frequently encountered and were very difficult to penetrate. The bulk of this area was heavily spiled and much of the distance was advanced behind breastboards.



Mono Craters Tunnel, Heading No. 1 at Sta. 1249+60, 15,260 ft. in from W. Portal showing approximately 1,500 g.p.m. of water, highly charged with CO_2, coming from test and pilot holes in the face. March, 1937.

Heading No. 4 was driven through various formations. Starting at Shaft No. 2, excavation was in good hard basalt for a few hundred feet, then through volcanic agglomerates, mostly very wet, then heavy sands and silts followed by a zone of andesitic agglomerates. About 2,000 feet of good sound andesite followed. While this formation stood

well without support, large flows of water were encountered which necessitated grouting. Beyond the andesite, driving was through several thousand feet of glacial gravels, followed by about 6,000 feet of granite and then into the metamorphics. Both the gravels and the granite were crossed by numerous faults, made large quantities of water, were heavy, and required heavy support. Several runs occurred in advancing through the gravels, one of which caused the suspension of driving operations for several months. During this period, all of the tunnel in heavy ground from the location of the run to the shaft was lined with concrete for greater safety.

The formations encountered in driving Heading No. 5 were alternately basalts and unconsolidated sands and gravels. In crossing an ancient stream bed about 1,500 feet from the shaft, the roof of the tunnel caved in, partially filling the tunnel with debris and flooding the tunnel and shaft, the latter to within 80 feet of the collar.

In driving Heading No. 6 the formations encountered were alternately volcanics—mostly basalts—and unconsolidated ancient lacustrine deposits consisting of beds of volcanic ash near the portal and beds of silts, sands, and gravels farther in the tunnel. Some of the silts, partially consolidated, would have a tendency to squeeze and "heaving" of the tunnel floor would occur. Very heavy timbering was required to hold this ground.

METHODS AND COSTS OF MINING AND CONCENTRATING CHROMITE*

MINING

The sudden and rapid growth of the chrome-mining industry in California and Oregon has resulted in drawing into it two classes of men, namely, those who have had no previous mining experience whatever, and those who have gained their experience from mining other ores. It is hoped the remarks that follow may in some cases be of use to the one class, and in some cases to the other. To those who have had no experience, we would say: get, if possible, a good mine foreman, who has learned his business from the bottom up and who has the knack of acquiring and holding the respect and goodwill of his men. The services of such a man are invaluable, and the price you can afford to pay for them is limited only by the magnitude of the operation. Next provide as good quarters for your men as the circumstances and probable duration of the operation will permit, and then see that they get good food, even if you seem to be losing money by supplying it.

In detail, the proper methods of mining will be governed by the circumstances surrounding each venture and these will vary quite as much between different mines as they will between those of enterprises based upon the exploitation of other minerals, but the chapter describing the irregularity and uncertainty of chrome deposits emphasizes the fact that in the mining of chromite more than that of any other mineral, the most important thing is to follow the ore. In doing this, any one of three methods may be available, namely, open-cut, tunnel, or shaft, of which the first is always the cheapest and the last the most expensive.

An outcrop, no matter how small, may be the only surface exposure of a large lens, or you may be able to see in it "all the ore there is." When such an outcrop is found on a hillside, an open-cut should be started upon it, and, if on level ground, a shaft should be started in the ore. In no case should a tunnel be started in barren ground for the purpose of driving under an outcrop, until it has been demonstrated by shaft or winze how deep the deposit goes, and then only after sufficient other work has been done to prove that enough ore exists to enable one to repay the cost of the tunnel out of the difference between the cost of hoisting or shoveling it and that of handling it by overhead stoping from the tunnel-level.

Again, in the case of a deposit that must be worked through a shaft, two questions may arise: (1) should the working shaft be located in the orebody itself, or on one side; and (2) what hoisting equipment should be used?

The first question can not be answered until work has been done on the orebody itself to determine its size and shape. Should it prove not to be more than fifteen or twenty feet deep, the hoisting could well

* Reprinted from a pamphlet "Chromite," by Alfred Burch and Samuel H. Dolbear, Mining and Scientific Press, 1918.

be done through an opening in the ore itself, for a windlass would probably be used and it could be shifted from one part of the deposit to another without great expense. Should the ore go to a greater depth, then its width, the shape at the top, and the firmness of the walls would determine where the shaft should be sunk; for, if the orebody is not more than about ten feet wide at the top, does not expand with depth, and has walls of fairly firm rock, then the headframe may be placed on stringers spanning the entire opening and no outside shaft will be needed. On the other hand, should any one of these conditions be reversed, it would probably be wise, in the case of a large orebody, to sink a shaft in the country-rock a short distance from the deposit after the preliminary prospecting in the ore had been performed.

The second question must be determined by the quantity of ore and the depth from which it is to be hoisted. For depths not greatly exceeding twenty feet, hoisting by windlass is probably as cheap as by any other method, though even to this depth should the orebody be large it might pay to carry an inclined track down through the middle of the deposit and hoist by gasoline-engine, steam, or, in a remote district, a horse-whim or 'whip.' No hard and fast rule can be established, but, as in the case of a proposed extraction tunnel, the probable number of tons available should be multiplied by the cost per ton of hoisting when employing the method involving the smallest investment for equipment, and by the cost per ton for each more expensive equipment. Whenever the difference is sufficient to repay the cost of the machinery less its salvage value, it should be installed. Costs of hoisting by different methods vary so greatly with different localities, depths, and tonnages, that no attempt will be made here to list them.

Most of the chromite deposits of California and Oregon are so small that drilling by hand is the method that must be adopted, and actual mining by this method is not as a rule much more expensive per ton of ore broken than by machine-drilling; but the latter method is much more rapid, thus reducing the overhead expense, and where labor is scarce, as it is in war times, the difference in the number of men necessary to produce a given tonnage is important. Therefore, whenever a deposit is found that appears large enough (dividing the cost of installation by the probable tonnage available), we would advise the use of compressed-air drills, for driving which there are several makes of portable and semi-portable air-compressors. It would be manifestly unwise, however, to wait 60 days for the erection of a compressed-air plant on a mine that could be worked out by hand in that length of time.

When the deposit is not large enough to justify building a concentrator for the purpose of separating ore from waste, it will be necessary to cob and sort the ore in order to produce a shipping product. In such mines a good foreman can frequently economize on the subsequent sorting by having his holes so placed as to break the spots of clean ore separate from the mixed material. This can be done more readily where hand-drilling is used instead of machine-work. For the actual cobbing it pays to provide special hammers formed like a geologist's hammer, but a little heavier; and it also pays to dump the ore over an inclined screen, so that the sorting is done upon the coarser material only. It also pays to spray the ore with water before sorting, and it is surprising how much spraying can be done through fine holes in a tin

can from a single barrel of water. It may be found that the screening from one lot of ore is sufficiently good to be shipped with the selected ore whereas that from the next lot will fall short of the requirements. If a good foreman be allowed, at the beginning of an operation, to take frequent samples of the screening for analysis, he will soon be able to judge fairly well whether a given pile should be shipped or put aside for concentrating later.

The cost of mining the product from a chrome mine in California varies within wide limits, although the actual breaking and tramming of the material from a medium orebody should not exceed the following prices per ton:*

	Hand-drilling	Machine-work
Open-cut	$1.50	$1.10
Overhead stoping from tunnel	2.25	1.75
Overhead stoping and hoisting through shaft	3.00	2.50
Underhand stoping	6.00	5.00

Added to these costs, however, are numerous items of overhead expense, which are frequently overlooked, for example, amortization of plant, workmen's compensation insurance, taxes, loss on boarding house, superintendence, sampling and analysis of samples, and various other items, which, for even a large operation may easily amount to a dollar per ton and for small ones may amount to several dollars per ton. What causes the greatest variation in the cost of mining, aside from differences in the size and form of the orebodies, is the relation between quantity of ore mined and of product shipped, for according as the ore is clean or badly mixed with waste, the sorting may range from as low as two dollars per ton up to as much as twenty.

CONCENTRATING

Many deposits of chromite that are too low-grade to be marketable will yield a good product as the result of concentration, but, before building a mill for that purpose, careful consideration should be given to some important questions.

(1) What profit per ton will the ore yield after paying all costs, including mining and concentration?

(2) How many tons are available, and is the quantity sufficient to re-pay the cost of the mill, leaving a profit?

(3) Is there an assured supply of water sufficient for the tonnage to be treated? About seven tons of water is required for each ton of ore.

(4) Is the ore itself amenable to concentration? What percentage of recovery and what grade of concentrate can be obtained?

(5) What is the type of equipment best adapted to the treatment of this particular ore?

The gravity concentration of chrome ores is an extremely simple operation, because the specific gravity of chromite is nearly double that of the usual gangue, which is mostly serpentine. The grade of the concentrate is determined not so much by the percentage of gangue remaining in it as by the grade of the clean mineral itself, which is variable.

* Year 1918.

For the final crushing of the ore after it has passed through the ordinary rock-breaker, a machine should be selected that will give a maximum of crushing capacity with a minimum of sliming. For this purpose we favor rolls. This practice has not been followed, however, by most mill-builders in California, where ball-mills and even stamps have been used for the final crushing; but whether this has been the result of careful design or due to the necessity for quick delivery of equipment is not known—the latter reason seems the more probable. Following the final crushing it has been the general practice to pass the material through some type of classifier to separate the sand from the slime. The sand is then passed over tables that discharge concentrate, middling and tailing, while the slime is treated on tables the products of which are concentrate and tailing. The middling from the sand-tables, without further grinding, is reconcentrated on another set of sand-tables.

A concentrator, including a rough building and gasoline-engines for power, can now be erected at points near a railroad in California or Oregon for about $300 per ton of daily capacity, or say, $15,000 for a 50-ton mill.

It is our belief that, because of the difference in the character of the ore in various deposits, such an important thing as the construction of a mill should not be undertaken without first having made preliminary tests upon the ore in a properly operated testing-plant and that then both the crushing and concentrating equipment should be selected to fit the requirements of the ore to be treated, and as most of the chrome ore that has come under our observation has been comparatively coarse in texture it is believed that for most cases, the equipment desirable will be about as follows: Rock-breaker, rolls working in a closed circuit with a 4 to 6-mm. trommel, fine jigs, rolls for jig-middling, working in closed circuit with Bunker Hill or Callow screen, classifier dividing the product to sand and slime tables, stationary canvas plant after slime-tables. Such a plant should not cost much more than the other type and on most chrome ores the percentage of recovery should be higher. Naturally, where fine grinding is really required for the purpose of liberating the mineral, ball-mills will be introduced for this work.

The recovery of chrome ore by concentration in California should be fully 75% of the mineral; with careful work and some refinements in practice it might be brought well above 80%. Too much money can not, however, be expended upon refinements for the benefit of a short-lived enterprise. The cost of concentration may be expected to range from less than one dollar per ton for a well-constructed 100-ton plant driven by cheap electric power up to two dollars, or more, for a small poorly constructed mill using gasoline-power.

CONCENTRATION BY METHODS OTHER THAN GRAVITY

Averill[1] gives the results of metallurgical concentrating tests on chrome ore from the Seiad Creek Chrome Deposit, Siskiyou County by six different methods of concentration. He states:

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[1] Averill, Chas. V., Mines and Mineral Resources of Siskiyou County, State Mineralogist's Report Vol. XXXI, No. 3, July, 1935.

"The accompanying diagram (Fig. 1) shows the results of experimental work done on the metallurgy, which is described in greater detail in a report by Gordon I. Gould, dated Feb. 20, 1934. In both table concentration and magnetic concentration, difficulty is experienced with the fine sizes that are unavoidably made in crushing and grinding. Good results can be obtained by both methods on sized material of about 40-mesh size; but results are poor on the 50% of

finer sizes that would be made. Much of the gangue is olivine, which approaches the specific gravity of chromite more closely than other gangues. On a concentrating table, the finer sizes of this are trapped in the concentrate. Three separate and distinct types of magnetic separator were used with the results indicated in the diagram. The magnetic permeability of chromite (particularly this chromite with its low iron content) is low, and the gangue has a slight permeability. In the finest sizes, this effect together with molecular attraction and dusting makes separation difficult. Best results were obtained by the Mississippi Valley Experiment Station of the U. S. Bureau of Mines, Rolla, Missouri, using flotation. The only details available on the

method used are given below: An acid circuit was used on account of the olivine-gangue. Ore tested assayed 32.17% chromite (Cr_2O_3).

Product	Weight (%)	Assay per cent Cr_2O_3.	Per cent of the Cr_2O_3.
Concentrate	46.3	57.76	83.1
Middling	13.2	22.88	9.4
Tailing	40.5	5.95	7.5

In the above test rougher concentrate assaying 50.02% Cr_2O_3 was cleaned twice, but one cleaner produced concentrate that assayed 56.35% Cr_2O_3 that represented a recovery of 89.7%. The chromite was floated in this test. Other tests were made on floating the gangue with good results, but not as good as those given above.

ADMINISTRATIVE

Walter W. Bradley, State Mineralogist

Personnel

Mr. Charles Volney Averill, who has been for a number of years in charge of the Redding branch office of the Division has been promoted from the classification of 'assistant mining engineer' to that of 'district mining engineer.'

New Publications

California Journal of Mines and Geology, October 1939, being Chapter 4 of State Mineralogist's Report XXXV. This chapter contains: 'Quicksilver Resources of California,' under the geologic branch; and a special article on 'Sulphate Minerals at the Leviathan Sulphur Mine, Alpine County.' This issue also contains the Index to Vol. XXXV, 1939.

Quicksilver Map of California. Available in advance of the above-noted 'Quicksilver Resources,' designed to accompany it but sold separately. Also carries geological and economic data.

Commercial Mineral Notes (Nos. 202-204) February, March, April, 1940, respectively. These 'Notes' contain the lists of 'mineral deposits wanted' and 'mineral deposits for sale,' issued in the form of a mimeographed sheet monthly. It is mailed free to those on the mailing list for 'California Journal of Mines and Geology.' As an evidence of the interest in mines and mineral resources now showing considerable activity, this mimeographed 'sheet' has had to be expanded to five pages in recent months.

Mail and Files

The Division of Mines maintains, in addition to its correspondence files and the library, a mine file which includes original reports on the various mines and mineral properties of all kinds in California.

During each quarterly period there are several thousand letters received and answered at the San Francisco office alone, covering almost every phase of prospecting, mining and developing mineral deposits, reduction problems, marketing of refined products and mining law. In addition to this, hundreds of oral questions are answered daily, both at the main office and the district offices, for the many inquirers who come in for personal interviews and to consult the files and library.

MINERALS AND STATISTICS

Statistics, Museum

Henry H. Symons, Statistician and Curator

STATISTICS

The counties of California have produced for some years past more than 50 different mineral substances, the total of which was estimated at $356,095,000 for 1939. See January, 1940, issue of the California Journal of Mines and Geology.

At present (April, 1940) reports for most of the producers are in hand. Data for several substances are now complete and have been compiled, being presented herein. Information at hand indicates that there was no commercial production during 1939 of the following: asbestos, bismuth, fluorspar, graphite, mica, mineral paint, serpentine, shale oil, or tin.

There was a single producer of each of the following: bromine, lithia, manganese ore, molybdenum ore, magnesite, potash, pyrite, strontium, titanium and wollastonite.

BENTONITE (Fuller's Earth)

During 1939 there was produced and shipped in California 11,284 short tons of bentonite (fuller's earth) valued at $138,854 from eleven properties—seven in San Bernardino, two in Kern County, and one each in Inyo, and San Benito counties. The 1939 output, as compared with that of 1938 showed an increase in amount and value, which was 9374 tons, worth $113,164.

Previous to 1931 the Division of Mines classed this material under the heading of 'fuller's earth,' but it was thought advisable to change the name to bentonite, owing to the fact that much bentonite is employed in uses that can not be classed as fuller's earth and therefore had been classified in these reports under pottery clay. This was somewhat confusing. Bentonite is the name commonly applied to the clays of the montmorillonite and halloysite group ('rock soap').

Fuller's earth includes many kinds of unctuous clays. It is usually soft, friable, earthy, nonplastic, white and gray to dark green in color, and some varieties disintegrate in water. Production has come mainly from Calaveras and Solano counties, with other deposits noted also in Riverside, Fresno, Inyo and Kern counties.

The Tariff Act of June 21, 1930, placed a duty of $1.50 a ton on foreign produced imported fuller's earth.

BITUMINOUS ROCK

This material is essentially an uncemented sandstone which is saturated with and held together by a natural asphaltic constituent, prob-

ably the residue from the evaporation of a crude petroleum deposit. Bituminous rock is still used to a limited extent for road dressing in those districts adjacent to available deposits, though the manufacture of asphalt at the oil refineries has almost entirely superseded the direct use of the native material. Some of the Santa Cruz County production is put on the market as a material which can be laid cold. This material is especially applicable and valuable for patch jobs.

During 1939 the output of bituminous rock amounted to 16,546 short tons valued at $63,612, coming from two properties in Santa Barbara County and one in Santa Cruz County. The 1939 production was a decrease in amount and value as compared wth that of 1938. The figure for 1938 were concealed under the 'Unapportioned' item so as not to reveal the annual output of a single operator in each Santa Barbara and Santa Cruz counties. The total of the 1937 and 1938 yield was 36,128 tons worth $139,242.

BORATES

During 1939 there was produced in California a total of 238,395 tons of borate materials compared with 240,899 tons for the year 1938. The material shipped during the year included the new sodium borates, kernite (rasorite), kramerite from Kern County; also crystallized borax prepared by evaporation of brines at Searles Lake in San Bernardino County and Owens Lake in Inyo County.

As the crude ore is not sold as such, but is almost entirely calcined before shipping to the refinery for conversion into the borax of commerce, and because of the fact that the material varied widely in boric acid content, we have recalculated the tonnage to a basis of 40 per cent, A. B. A. This is approximately the average A. B. A. content of colemanite material after calcining, and also of the crystallized borax obtained from evaporation of the lake brines.

Recalculated as above, the 1939 production totaled 244,819 tons, valued at $5,110,807. This was a decrease both in quantity and value over the 1938 output, which was 276,144 tons worth $5,014,237.

An increase in the total amount of borates exported from the United States [1] during the year 1939 was 91,139 tons valued at $3,230,-304 as compared with 77,519 tons worth $2,642,446 in 1938.

CEMENT

During 1939 there was a production of 10,984,033 barrels of cement in California valued at $15,616,219 f.o.b. plant; of which 4,645,-901 barrels came from northern California plants and 6,338,132 barrels from southern California plants. The 1939 output showed a slight increase in both amount and value as compared with that of 1938 which was 10,561,037 barrels worth $15,502,574.

Shipments during 1939 were made from ten plants in nine counties to the extent of 11,219,575 barrels valued at $16,015,655, as compared with 10,594,706 barrels worth $15,567,295. There were five plants in operation in northern California, one each in Calaveras, Contra Costa, Merced, San Mateo, Santa Cruz counties, which shipped 4,785,901 bar-

[1] Monthly Summary of Foreign Commerce of the United States, Department of Commerce, December, 1939.

rels of cement; and five plants in southern California, two in San Bernardino County and one each in Kern, Los Angeles [1] and Riverside counties, which shipped 7,747,301 barrels of cement. There were 1825 men employed in the above plants during the year 1939.

GYPSUM

During 1939 there were shipments of gypsum in California amounting to 219,671 short tons valued at $437,343, coming from three properties each in Fresno and Kern counties and one each in Imperial, Monterey and Riverside counties. In addition to the above figures there was a considerable amount of gypsum coming from Alameda County, which was obtained in the chemical process of reducing magnesium salts from bittern water with lime, the amount of which is not included in the above data, as the figures are already contained in those of magnesium salts and lime. The 1939 output was the largest annual recorded in this State and as compared with the 1938, which was 161,996 tons worth $327,821.

LIME

In California during 1939 there was an output of lime amounting to 87,288 short tons valued at $849,122 coming from two plants each in El Dorado and San Bernardino counties; and one each in Alameda, Inyo, Santa Cruz and Tuolumne counties. The above figures showed an increase in both amount and value over those of 1938 which were 70,578 tons worth $682,403.

The 1939 figures on lime were the largest of any annual output on record for California.

So far as we have been able to segregate the data, these figures include mainly only such lime as is used in building operations; though they do include a small proportion of calcined lime employed in agriculture and the chemical industries, the figures for which were not separable. A portion is hydrated lime. Limestone utilized in sugar making, for smelter flux, as a fertilizer, and other special industrial uses, is classified under 'Industrial Materials.' That consumed in cement manufacture is included in the value of cement.

LIMESTONE

'Industrial' limestone was produced by twenty-two properties in twelve counties in California during 1939 to the amount of 316,029 short tons valued at $838,235, this being an increase in amount and value over the 1938 figures which were 302,655 tons worth $729,149. The 1939 yield came from four properties in El Dorado County; three each in San Bernardino, Santa Clara, and Santa Cruz counties; two in Tuolumne County; and one each in Fresno, Imperial, Inyo, Los Angeles, Riverside, San Luis Obispo and San Mateo counties.

The amount here given does not include the limestone used in the manufacture of cement nor for macadam and concrete, nor of lime for building purposes; but accounts for that utilized as a smelter and foundry flux, for glass and sugar making, and other special chemical and manufacturing processes. It also includes that utilized for ferti-

[1] The plant in Los Angeles County grinds clinker coming from other counties, therefore the crude material is credited to the point of origin.

lizers (agricultural 'lime'), 'roofing gravel,' paint and concrete filler, whiting for paint, putty, kalsomine, terrazzo, paving dust, chicken grit, carbon dioxide gas, 'paving compound,' facing dust for concrete pipe, also for rubber and magnesite mix. The material from Fresno County was marl; and that from Alameda, San Mateo and Santa Clara counties was shells, dredged from San Francisco Bay, which were ground and used for agricultural purposes and poultry grit. Of the total 'industrial' limestone produced in 1939, approximately 94,396 tons valued at $346,584 was used for agricultural purposes and poultry grits.

Distribution of the 1939 output of limestone was as follows:

County	*Tons*	*Value*
El Dorado	146,625	$320,212
San Bernardino	18,710	60,703
Santa Clara	59,151	117,763
Santa Cruz	34,837	47,529
Fresno,[a] Imperial, Inyo, Los Angeles, Riverside, San Luis Obispo, San Mateo,[b] and Tuolumne *	56,706	292,028
Totals	316,029	$838,235

* Combined to conceal the output of individual operators in each.
[a] Includes marl.
[b] Includes shells.

PUMICE AND VOLCANIC ASH

The production of pumice and volcanic ash in California during 1939, amounted to 41,109 short tons valued at $159,951. This output came from four properties in Siskiyou County; three in Inyo County; two each in Kern, Mono, and Napa counties; and one each in Amador, Modoc and San Luis Obispo counties. The 1939 figures showed an increase in both amount and value over those of 1938, which were 18,783 tons worth $105,207.

The material from Inyo, Modoc, Mono, Napa, and Siskiyou counties was 31,481 tons of lump pumice, which was used in acoustic plaster, light-weight aggregate in concrete, for abrasive purposes, scouring bricks, and for chicken-house litter. That from Amador, Kern, Madera, and San Luis Obispo counties was 9,628 tons of volcanic ash, or tuff variety, and was employed in making soap, cleanser compounds, as a concrete filler in cement displacement, in asphalt, and as a carrier for dry agricultural sprays. The Kern County ash is going into the preparation of one of our popular and nationally advertised brands of cleanser compounds.

QUICKSILVER

The production of quicksilver in California during 1939 amounted to a total of 11,201 flasks valued at $1,102,563, compared with 12,171 flasks worth $846,497 in 1938. The 1939 output came from 78 properties in eighteen counties and was distributed as follows:

County	*Flasks*	*Value*
Kings	25	$2,583
Lake	4,155	416,150
Monterey	11	1,151
Napa	691	71,823
San Benito	3,860	360,567
San Luis Obispo	276	26,587
Santa Barbara	74	6,876
Santa Clara	252	26,098
Sonoma	255	27,212
Contra Costa, Fresno, Kern, Mono, Orange, Solano, Trinity, and Yolo*	1,602	163,516
Totals	11,201	$1,102,563

* Combined to conceal the output of individual operators.

SALT

Most of the salt production in California is obtained by evaporation of water of the Pacific Ocean, plants being located on the shores of San Francisco, Monterey, and San Diego bays, and at Long Beach. Additional amounts are derived from lakes and lake beds in the desert regions (in part, rock salt), mainly in Imperial, Kern, and San Bernardino counties, and evaporation of alkaline lake water in Modoc County. A small amount of valuable medicinal salts has been obtained by evaporation of the water of Lake Mono, Mono County, and from a mineral spring in Butte County.

During 1939 there was an output in California of 417,956 tons of salt worth $1,174,386, compared with 395,746 tons worth $1,044,325 in 1938. There were fifteen companies operating plants in 1939, two in San Bernardino County and one each in Butte, Imperial, Kern, Los Angeles, Mono, Modoc, Monterey, Orange, San Diego, and San Mateo, and three in Alameda County.

The average value reported for salt produced in California during 1939 was $2.81 per ton f.o.b. plant, compared with $2.78 in 1938; $2.82 in 1937; $3.08 in 1936; $3.36 in 1935; and $3.68 in 1934.

SILICA (Sand and Quartz)

We combine these materials because of the overlapping roles of vein quartz which is mined for use in glass making and as an abrasive, and that of silica sand which, although mainly utilized in glass manufacture, also serves as an abrasive. Both varieties are also utilized to some extent in fire-brick manufacture.

We do not include under this heading such form of silica as: quartzite, sandstone, flint, tripoli, diatomaceous earth, nor the gem forms of 'rock crystal,' amethyst, and opal. Each of these has various industrial uses, which are treated under their own designations.

The production of silica in California during 1939 amounted to 86,229 short tons valued at $349,074 f.o.b. rail shipping point, and came from two properties in Contra Costa County and one each in Orange, Riverside, and San Diego counties. The above was an increase in both amount and value over the output of 1938 which was 63,176 tons worth $278,676. The 1939 output consisted of 84,979 tons of glass sand and 1250 tons of vein or boulder quartz—the largest annual

recorded production of silica in this State. This is brought about by increased production of glass sand.

The glass sand came from Contra Costa, Orange and Riverside counties. For making the higher grades of glass, deposits in Contra Costa County are replacing the sand imported from Belgium. Belgium sand has displaced local material in the manufacture of sodium silicate ('water glass'). There are various deposits of quartz in California which could be utilized for glass making, but to date they have not been so used owing to the cost of grinding and the difficulty of preventing contamination by iron while grinding.

Silica sand has been produced in the following counties of the State: Alameda, Amador, Contra Costa, El Dorado, Imperial, Inyo, Los Angeles, Mariposa, Mono, Monterey, Orange, Placer, Riverside, San Diego, San Joaquin and Tulare, the chief centers being Contra Costa, Amador, Monterey and Los Angeles counties. The industry is of limited importance, so far, because of the fact that much of the available material is not of a grade which will produce first-class colorless glass; for such, it must be essentially iron-free. Even a fractional per cent of iron imparts a green color to the glass.

The Tariff Act of June 21, 1930, placed a duty on sand, containing 95 per cent or more of *Silica* and not more than six-tenths of 1 per cent of oxide of iron and suitable for use in the manufacture of glass, of $2 per ton.

SLATE

Slate was first produced in California in 1889. Up to and including 1910 such production was continuous, but since then it has been irregular. Large deposits of excellent quality are known in the State, especially in El Dorado, Calaveras and Mariposa counties, but the demand has been light owing principally to competition of cheaper roofing materials.

The production of slate in California during 1939 amounted to 5,777 short tons, having a total value of $28,329 f.o.b. quarry and came from properties in Calaveras, El Dorado, Los Angeles and Tuolumne counties. The 1939 figures showed a decrease in both amount and value over those of 1938 which were 6,871 tons at $30,281. Practically all the slate was crushed and used for roofing granules. The slate from Los Angeles County was sold as flagstone.

SOAPSTONE AND TALC

The total output of talc and soapstone in California during 1939 amounted to 31,820 short tons valued at $371,078. This was an increase in both quantity and value over the 1938 figures, which were 28,346 tons valued at $290,810. Of the 1939 production, 30,241 tons were high-grade talc from Inyo and San Bernardino counties, which material was utilized mainly in toilet powders, paint, paper, for rubber manufacture, and some in ceramics. The remainder of 1,579 tons was soapstone and came from Butte, El Dorado, and Los Angeles counties. The 1939 figures for soapstone and talc are the largest of any year recorded in California.

The 'soapstone' grades were used mainly for roofing granules and as a filler in roofing paper and part also in magnesite cement.

It is reported that California talc has replaced to some extent imported talc in the toilet trade on the basis of quality. The largest production of talc in the United States comes from Vermont and New York and of massive soapstone from Virginia.

During 1939 imports of talc steatite, etc., totaled 26,267 tons valued at $452,619, as compared with 22,127 tons worth $391,198 during 1938, according to the United States Bureau of Foreign and Domestic Commerce.

The Tariff Act of 1930 places a duty on talc, steatite or soapstone and French chalk, crude or unground, of one-fourth of one cent per pound.

SODA

The production of sodium salts in California in 1939 included: Soda ash, and trona from plants at Owens Lake, Inyo County; and soda ash, salt cake, and trona ('sesqui-carbonate,' a double salt of Na_2CO_3 and $NaHCO_3$) from Searles Lake, San Bernardino County. There were no shipments of salt cake (sulphate) from Carrizo Plains, San Luis Obispo County. The output for 1939 amounted to 200,049 short tons valued at $2,055,608, as compared with 178,105 tons worth $2,023,610 in 1938. The figures for 1939 were the largest on record.

The dense ash and bicarbonate were used mainly in the manufacture of soap, glass, paper, oil refining, sugar refining, and chemicals; and the trona for metallurgical purposes.

TUNGSTEN

The commercial production of tungsten ores and concentrates in California began in 1905; and has been continuous since, with the exception of 1920-1922 inclusive. The material shipped in 1939 was high-grade sorted ore and concentrates, coming from four properties in Inyo County, two in San Bernardino County, and a single property each in Fresno, Kern, Mono, and Tulare counties. A total of 1.221 short tons of concentrates averaging 60.70% WO_3 was reported shipped yielding 74,110 units, or 1,235 tons recalculated to 60% WO_3 and valued at $1,153,735 at the mine. The 1939 output showed an increase in both quantity and value as compared with that of 1938, which was 736 tons worth $786,860.

Quotations in ''Metal and Mineral Markets'' during 1939 for Chinese wolframite duty paid started the year at $19.50 a unit WO_3. Increase in price in September was $23.00 a unit WO_3, and the end of the year, at $22.50 a unit WO_3. Domestic scheelite started the year at $16 to $19 a unit WO_3, in September reached $25 a unit WO_3 and ended the year at from $22 to $25 a unit WO_3. Present (April, 1940) prices per unit WO_3 at New York are: Chinese wolframite, duty paid, $23; Scheelite, $22 to $23.

Imports of foreign tungsten ores and alloys in the United States during 1939, according to the U. S. Bureau of Foreign and Domestic Commerce, totaled 2,743,472 pounds valued at $997,971, compared with 322,085 pounds worth $138,693 in 1938. The Tariff Act of 1930 raised the duty on tungsten ore or concentrates to 50 cents per pound on the metallic tungsten contained therein. Duties are also provided for imported tungsten-bearing alloys.

Tungsten ore has been produced in California principally in the Atolia-Randsburg district in San Bernardino and Kern counties, followed by the Bishop district in Inyo County, with small amounts coming from Nevada County and from the district near Goffs, in eastern San Bernardino. Most of California's tungsten ore is scheelite, calcium tungstate), though wolframite (iron-manganese tungstate) and hübernite (manganese tungstate) also occur. The deposits at Atolia are the largest and most productive scheelite deposits known previous to 1930.[1] (Since passed by Mill City, Nevada.)

MUSEUM

The Museum of the State Division of Mines possesses an exceptionally fine collection of rocks and minerals of both economic and academic value. It ranks among the first five of such collections in North America and contains not only specimens of most of the known minerals found in California, but much valuable and interesting material from other states and foreign countries as well.

The exhibit is daily visited by engineers, students, business men, and prospectors as well as tourists and mere sightseers. Besides its practical use in the economic development of California's mineral resources, the collection is a most valuable educational asset to the state and to San Francisco.

Mineral specimens suitable for exhibit purposes are solicited, and their donation will be appreciated by the State Division of Mines as well as by those who utilize the facilities of the collection.

Among the specimens received recently and catalogued for the Museum are the following:

20997 BRUCITE, $Mg(OH)_2$, a magnesium hydroxide, well crystallized.
Locality: Nye County, Nevada.
Donor: R. A. Lohse.
February, 1940.

20998 CRISTOBALITE (Sio_2), with FALALITE (Fe_2Sio_4), in obsidian.
Locality: Little Lake, Inyo County, California.
Donor: R. A. Lohse.
February 9, 1940.

20999 PERLITE variety of OBSIDIAN.
From San Bernardino County, California.
Donor: Robert M. Parker.
February, 1940.

21000 SCHEELITE ($CaWo_4$), transparent crystal, with associated GARNET.
From ten miles southwest of Springville, Tulare County, California.
Donor: R. F. Bibb.
February, 1940.

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[1] U. S. G. S. Bull. 652, p. 32.

21001 GOLD NUGGET, replica of Golden Bear.
Found in Placer County, in 1857.
The original was on display here for many years. Now owned by California Federation of Mineralogical Societies.
February, 1940.

21002 KIMBERLITE (diamond rock) having several small diamonds from 3000 ft. level of the Bultfonlein Mine, Bacon Field district, Kimberley, South Africa.
February, 1940.
Donor: Charles H. Soar.

21003 TINCAL, dehydrated crystals, with HANKSITE in a matrix of Halite and Trona, from depth of 65 ft.
Well 43, Searles Lake, San Bernardino County, California.

21004 SILVER-GOLD ORE, pyritic.
Locality: Morning Star Mine, near Markleeville, Alpine County, California.
Donor: Walter W. Bradley.
March, 1940.

21005 Native IRON in BASALT.
From Disco Island, Greenland.
Exchange.
April, 1940.

21006 ARISPE METEORITE, iron, coarse octahedrite: Two masses, 116 lbs. and 201 lbs.
Found 25 miles northwest of Arispe, Sonora, Mexico, in 1896; and another mass of 272 lbs. found 15 miles northwest of Arispe in 1898. Most of it is now on display at National Museum, Washington, D. C.; Weight of slice, 5 lbs.
Exchange.
April, 1940.

21007 SALTA METEORITE, stony-iron, pallasite.
From Salta, Argentina.
Entire mass in U. S. National Museum, Washington, D. C.
Weight of mass, 27 kgs.
Weight of slice, 394 grams.
Exchange.
April, 1940.

21008 SIERRA GORDA METEORITE, iron hexahedrite.
From Sierra Gorda, Chile.
Entire mass in U. S. National Museum, Washington, D. C.
Weight of mass, 22 kgs.
Weight of slice, 430 grams.
Exchange
April, 1940.

21009 SILICA SAND, 20 to 30 mesh.
From Ottawa, La Salle County, Illinois.
Donor: A. M. M. Russell.
April, 1940.

21010 JASPER
Polished by F. J. Sperisen.
From near Morgan Hill, Santa Clara County, California.
Donor: Robert M. White.
April, 1940.

21011 PETRIFIED GINKO WOOD, the connecting link between the old coniferous and present hard wood.
From Vantage Ferry, Washington.
Donor: Arthur J. Walker.
April, 1940.

21012 MANGANESE Metal produced by method developed by the U. S. Bureau of Mines by Electric Manganese Corporation, at plant in Knoxville, Tennessee.
Donor: Charles W. Merrill.
April, 1940.

8—88203

LABORATORY

GEORGE L. GARY, Mineral Technologist

Since 1866 many lists have been published showing localities of California minerals. The last one, ''Minerals of California,'' by Adolph Pabst, was published in 1938 by the Division of Mines as Bulletin 113.

It is the intention of the Division of Mines to publish in the quarterly new localities for minerals that are received by the laboratory for determination. So that this information may be accurate, it is requested that all specimens submitted for classification be accompanied by a letter giving the exact location where the material was found.

Corrections will also be noted as well as additions when called to our attention.

73. Massive green fluorite, a calcium fluoride occurs about four miles southeast of Kelseyville, Lake County.

74. Garnierite, a hydrous magnesium and nickel silicate occurs near Lotus, El Dorado County.

75. Hydromagnesite, a hydrous magnesium carbonate is found as chalky balls in nickeliferous serpentine near Cloverdale, Sonoma County.

LIBRARY

JOHN C. O'BRIEN, Librarian

In addition to the numerous standard works, authoritative information on many phases of the mining and mineral industry is constantly being issued in the form of reports and bulletins by various government agencies.

The library of the Division of Mines contains over six thousand selected volumes on mines, mining and allied subjects, and it is also a repository for reports and bulletins of the technical departments of federal and state governments and of educational institutions, both domestic and foreign.

It is not the dearth of the latter publications, but rather a lack of knowledge of just what has been published and where the reports may be consulted or obtained, that embarrasses the ordinary person seeking specific information.

To assist in making the public acquainted with this valuable source of current technical information, CALIFORNIA JOURNAL OF MINES AND GEOLOGY contains under this heading a list of all books and official reports and bulletins received which pertain particularly to mining in California.

Files of all the leading technical journals will be found in the library, and county and state maps, topographical sheets and geological folios. Current copies of local newspapers published in the mining centers of the state are available for reference.

The library and reading room are open to the public during the usual office hours, when the librarian may be freely called upon for all necessary assistance.

OFFICIAL PUBLICATIONS RECEIVED WHICH HAVE SPECIAL INTEREST OR REFERENCE TO CALIFORNIA

Governmental, National:

U. S. Gelogical Survey:

Topographic Maps:

- Avawatz Mountains Quadrangle.
- Boneyard Canyon Quadrangle.
- Buena Vista Lake Quadrangle.
- Compton Quadrangle.
- La Crescenta Quadrangle.
- Mt. Emma Quadrangle.
- San Jose Quadrangle.

U. S. Bureau of Mines:

Technical Papers:

600 Review of the Literature on the Construction, Testing and Operation of Laboratory Fractionating Column.

602 Inspection and Maintenance of Mine Hoisting Ropes.

Miner's Circular.

39 Central Mine Rescue Stations.

Information Circulars:

7093 Reconnaissance of Mining Districts in Churchill County, Nevada, by William O. Vanderburg.

7094 Mining Methods and Costs at the South Burns Shaf of Golden Conqueror Mines, Inc., Cripple Creek, Colorado, by Albert S. Konselman.

7099 Accident Experience of Four Louisiana Petroleum Refineries, 1929-38, by F. E. Cash and Erick H. Brown.

7105 Annual Report of Research and Technologic Work on Coal, Fiscal Year 1939, by A. C. Fieldner and R. E. Brewer.

Report of Investigations:

3480 Progress Reports—Metallurgical Division. Annual Report of the Metallurgical Division, Fiscal Year, 1939, by R. S. Dean.

3483 Progress Reports—Metallurgical Division. Recovery of Nickel, Copper, and Precious Metals from Domestic Ores by a Combined Electrothermal and Electrolytic Method, by J. Koster, R. G. Knickerbocker, O. C. Garst, T. E. Evans, and W. E. Cody.

3484 Progress Reports—Metallurgical Division. Ore-Testing Studies, 1938-1939 (Primarily Ore-Dressing), by A. L. Engel and S. M. Shelton.

3485 Survey of Fuel Consumption at Refineries in 1938, by G. R. Hopkins.

3486 Survey of Crude Oils of the Producing Fields of Arkansas, by O. C. Blade and George C. Branner.

3487 Tests on the Effect of Acid Mine Waters on Various Cements, by R. D. Leitch and J. G. Calverley.

3488 Use of Respiratory Protective Devices Under Abnormal Air Pressure, by F. E. Griffith and H. H. Schrenk.

3489 Explosibility of Semianthracite, Low-Volatile Bituminous-Coal and Medium-Volatile Bituminous-Coal Dusts, by H. P. Greenwald.

3492 Cooperative Fuel Research Motor-Gasoline Survey, Summer 1939, compiled by E. C. Lane.

3493 Application of Well-Test Data to the Study of a Specific Gas-Production Problem, by M. A. Schellhardt, E. J. Dewees, and W. H. Barlow.

3494 Flocculation as an Aid in the Clarification of Coal Washery Water, by H. F. Yancey, R. E. Zane, Walter Wood, and J. T. H. Cannarella.

3495 The Eykometer, a New Device for Measurement of the Yield Point of Clay Suspensions and Oil-Well Drilling Muds, by A. George Stern.

3499 Combustibility of Coke in Air.

3501 Annual Report of the Petroleum and Natural-Gas Division, Fiscal Year, 1939.

U. S. Department of the Interior:

Bureau of Reclamation:

Boulder Canyon Project.

All American Canal System Map No. 39-44A.

Books:

Annual Report of the Director of the Mint for the Fiscal Year Ended June 30, 1939. Including Report on the Production of the Precious Metals During the Calendar Year, 1938.

Inventory of the County Archives of California No. 41, San Luis Obispo Co., by The Northern California Historical Records Survey Project—Works Project Administration.

Annual Report of the Chief of Engineers, U. S. Army.
Part 1, Vols. 1 and 2, 1939.
Part 2, 1939.

Jewelry Gem Cutting and Metalcraft, by William T. Baxten.

Geology and Engineering, by Robert F. Legget.

Principles of Mineral Dressing, by A. M. Goudin.

PUBLICATIONS RECEIVED CURRENTLY AND FORMER REPORTS AVAILABLE FOR REFERENCE

Governmental, State.

Alabama Geological Survey, University.
Arizona Bureau of Mines, Tucson.
Arkansas Geological Survey, Little Rock.
Colorado Bureau of Mines, Denver.
Connecticut Geological and Natural History Survey, Hartford.
Florida Department of Conservation, Tallahassee.
Georgia Division of Geology, Atlanta.
Idaho Bureau of Mines and Geology, Moscow.
Illinois Geological Survey, Urbana.
Iowa Geological Survey, Des Moines.
State Geological Survey of Kansas, Lawrence.
Kentucky Geological Survey, Frankfort.
Louisiana Department of Conservation, New Orleans.
Maine State Geologist, Augusta.
Maryland Geological Survey, Baltimore.
Michigan Geological Survey, Lansing.
Minnesota Geological Survey, Minneapolis.
Mississippi State Geological Survey, University.
Missouri Bureau of Geology & Mines, Rolla.
Montana Bureau of Mines and Geology, Butte.
Nebraska Geological Survey, Lincoln.
Nevada State Bureau of Mines, Reno.
New Jersey Department of Conservation and Development, Trenton.
New Mexico Bureau of Mines and Mineral Resources, Socorro.
North Carolina Geological & Economic Survey, Chapel Hill.
North Dakota Geological Survey, Grand Forks.
Ohio Geological Survey, Columbus.
Oklahoma Geological Survey, Norman.
Oregon State Department of Geology and Mineral Industries, Portland.
Pennsylvania Topographic and Geological Survey, Harrisburg.
South Dakota State Geological Survey, Vermillion.
Tennessee Division of Geology, Nashville.
Texas Bureau of Economic Geology, Austin.
Virginia Geological Survey, University.
Washington State Department of Conservation and Development, Pullman.
West Virginia Geological Survey, Morgantown.
Wisconsin Geological & Natural History Survey, Madison.
Wyoming Geological Survey, Cheyenne.

Governmental, Foreign.

Alberta Research Council, Edmonton.
Argentina Direccion General de Minas y Geologica, Buenos Aires.
British Columbia Minister of Mines, Victoria.
British Museum and Natural History, London.
Canada Department of Mines, Ottawa.
Cuerpo de Ingenieros de Minas y Aguas del Peru, Lima.
Geological Service of Minas Geraes, Bella Horizonte, Brazil.
Geological Survey of Scotland.
Instituto Historica e Geographico Rio de Janeiro.
Museo de Historia Natural de Montevideo, Uruguay.
New South Wales Department of Mines, Sydney, Australia.
New Zealand Geological Survey Branch, Wellington.
Nova Scotia Department of Public Works and Mines, Halifax.
Ontario Department of Mines, Toronto, Canada.
Quebec Bureau of Mines, Quebec.
Queensland Department of Mines, Brisbane, Australia.
South Australia Department of Mines, Adelaide.
Transvaal Chamber of Mines, Johannesburg, South Africa.
Western Australia, Geological Survey, Perth.

Societies and Educational Institutions.

Academia de Ciencias y Artes de Barcelona, Spain.
Academy of Natural Sciences, of Philadelphia.
American Association of Petroleum Geologists, Tulsa, Oklahoma.
American Geographical Society of New York.
American Institute of Mining and Metallurgical Engineers, New York.
American Journal of Science, New Haven, Conn.
American Philosophical Society, Philadelphia.
Australian Museum, Sydney.
California Academy of Sciences, San Francisco.
Carnegie Institution of Washington.
Cleveland Museum of Natural History, Cleveland, Ohio.
Colorado College Publications, Colorado Springs.
Colorado Scientific Society, Denver.
Commonwealth Club, San Francisco.
Economic Geology, Lancaster, Pa.
Field Museum of Natural History, Chicago.
Franklin Institute of the State of Pennsylvania, Lancaster, Pa.
Geological Society of America, Columbia University, New York.
Geographical Society of London.
Institution of Mining and Metallurgy, London.
Instituto Geologico de Mexico, Mexico, D. F.
Journal of Geology, Chicago.
Mineralogical Society of America, Menasha, Wisconsin.
Michigan College of Mining and Technology, Houghton.
Mining and Metallurgical Society of America, New York.
Museu Nacional, Rio de Janeiro.
National Research Council, Washington, D. C.
New York Academy of Sciences, New York.
New York State Museum, Albany.
Pennsylvania State College, State College.
Philippine Journal of Science, Manila.
Royal Society of South Australia, Adelaide.
Seismological Society of America, Stanford University.
Sierra Club, San Francisco.
Society of Economical Paleontologists and Mineralogists, Fort Worth, Texas.
Southern California Academy of Sciences, Los Angeles.
University of California Publications in Engineering, Berkeley.
University of California Publications in Geography, Berkeley.
University of California Publications in Geology, Berkeley.
University of Harvard, Department of Mineralogy and Petrography, Cambridge, Mass.

Current Magazines on File.

For the convenience of persons wishing to consult the technical magazines in the reading room, a list of those on file is appended:

Asbestos, Philadelphia, Pennsylvania.
Brick and Clay Record, Chicago.
California Journal of Development, San Francisco.
California Mining Journal, Auburn.
California Oil World, Los Angeles.
California Safety News, San Francisco.
Canadian Mining Journal, Gardenvale, Quebec.
Chemical and Metallurgical Engineering, New York City.
Chemical Engineering and Mining Review, Melbourne, Australia.
Civil Engineering, New York City.
Colorado School of Mines, Golden, Colorado.
Conservationist, Sacramento, California.
Engineering and Mining Journal, New York City.
Fuel Oil, Chicago, Illinois.
Fusion Facts, Whittier, California.
Gemmologist, London.
Gold, Toronto, Canada.

Grizzly Bear, Los Angeles.
Hercules Mixer, Wilmington, Delaware.
Independent Monthly, Tulsa, Oklahoma.
Lubrication, The Texas Co., New York City.
Metals and Alloys, Pittsburgh, Pennsylvania.
Mine and Mill World Digest, San Francisco.
Mining and Contracting Review, Salt Lake City.
Mineralogist, Portland, Oregon.
Mining Congress Journal, Washington, D. C.
Mining and Industrial News, San Francisco.
Mining and Geological Journal, Melbourne, Victoria, Australia.
Mining Journal, London.
Mining Journal, Phoenix, Arizona.
Mining and Metallurgy, New York City.
Mining Review, Salt Lake City.
Nevada Mining Bulletin, Las Vegas, Nevada.
Nickel Steel Topics, New York City.
Northwest Mining, Spokane, Washington.
Northwest Science, Cheney, Washington.
Oil and Gas Journal, Tulsa, Oklahoma.
Oil, Paint and Drug Reporter, New York City.
Oil Weekly, Houston, Texas.
Pacific Purchaser, San Francisco.
Pacific Chemical and Metallurgical Industries, San Francisco.
Petroleum World, Los Angeles.
Queensland Government Mining Journal, Brisbane, Australia.
Rock Products, Chicago.
Rocks and Minerals, Peekskill, New York.
Sands, Clays and Minerals, Chatteris, England.
Scientific American, New York City.
Southwest Builder and Contractor, Los Angeles.
Stabilizer, Los Angeles.
Standard Oil Bulletin, San Francisco.
Stone, New York City.
Western Mining News, San Francisco.

Newspapers.

The following papers are received and kept on file in the library:

Alaska Weekly, Seattle, Washington.
Amador Dispatch, Jackson, California.
Banner, Sonora, California.
Barstow Printer, Barstow, California.
Bridgeport Chronicle-Union, Bridgeport, California.
Calaveras Californian, Angels Camp, California.
Calaveras Prospect, San Andreas, California.
Colusa Sun-Herald, Colusa, California.
Daily Commercial News, San Francisco, California.
Daily Midway Driller, Taft, California.
Del Norte Triplicate, Crescent City, California.
Denver Mining Record, Denver, Colorado.
Georgetown Gazette, Georgetown, California.
Inyo Independent, Independence, California.
Inyo Register, Bishop, California.
Las Vegas Age, Las Vegas, Nevada.
Livermore Herald, Livermore, California.
Los Angeles Times, Los Angeles, California.
Mariposa Gazette, Mariposa, California.
Mercury Register, Oroville, California.
Mohave Miner, Kingman, Arizona.
Mojave-Randsburg Record, Mojave, California.
Morning Union, Grass Valley, California.
Mountain Messenger, Downieville, California.
Needles Nugget, Needles, California.
Nevada City Nugget, Nevada City, California.

Nevada Mining Bulletin, Las Vegas, Nevada.
Oil Marketer, Bayonne, New Jersey.
Placer Herald, Auburn, California.
Plumas Independent, Quincy, California.
San Diego News, San Diego, California.
Shasta Courier, Redding, California.
Siskiyou News, Yreka, California.
Stockton Record, Stockton, California.
Tehachapi News, Tehachapi, California.
Terra Bella News, Terra Bella, California.
Tuolumne Independent, Sonora, California.
Tuolumne Prospector, Tuolumne, California.
Union Democrat, Sonora, California.
Ventura County News, Ventura, California.
Waterford News, Waterford, California.
Weekly Trinity Journal, Weaverville, California.
Western Mineral Survey, Salt Lake City, Utah.
Western Sentinel, Etna Mills, California.

PRODUCERS AND CONSUMERS

The producer and consumer of mineral products are mutually dependent upon each other for their prosperity, and one of the most direct aids rendered by this Division to the mining industry in the past has been that of bringing producers and consumers into direct touch with each other.

This work has been carried on largely by correspondence, supplemented by personal consultation. Lists of buyers of all the commercial minerals produced in California have been made available to producers upon request, and likewise the owners of undeveloped deposits of various minerals, and producers of them, have been made known to those looking for raw mineral products.

When the publication of *Mining in California* was on a monthly basis, current inquiries from buyers and sellers were summarized and lists of mineral products or deposits 'wanted' or 'for sale' included in each issue.

It is important that inquiries of this nature reach the mining public as soon as possible and in order to avoid the delay incident to the present quarterly publication of California Journal of Mines and Geology, these lists are now issued monthly in the form of a mimeographed sheet under the title of 'Commercial Mineral Notes,' and sent to those on the mailing list of California Journal of Mines and Geology.

EMPLOYMENT SERVICE

Following the establishment of the Mining Division branch offices in 1919, a free technical employment service was offered as a mutual aid to mine operators and technical men for the general benefit of the mineral industry.

Briefly summarized, men desiring positions are registered, the cards containing an outline of the applicant's qualifications, position wanted, salary desired, etc., and as notices of 'positions open' are received, the names and addresses of all applicants deemed qualified are sent to the prospective employer for direct negotiations.

Telephone and telegraphic communications are also given immediate attention.

Technical men, or those qualified for supervisory positions, and vacancies of like nature only, are registered, as no attempt will be made to supply common mine and mill labor.

Registration cards for the use of both prospective employers and employees may be obtained upon request, and a cordial invitation is extended to the industry to make free use of the facilities afforded. Parties interested should communicate direct with our San Francisco office.

PUBLICATIONS OF THE DIVISION OF MINES

During the past fifty-six years, in carrying out the provisions of the organic act creating the former California State Mining Bureau, there have been published many reports, bulletins and maps which go to make up a library of detailed information on the mineral industry of the State, a large part of which could not be duplicated from any other source.

One feature that has added to the popularity of the publications is that many of them have been distributed without cost to the public, and even the more elaborate ones have been sold at a price which barely covers the cost of printing.

Owing to the fact that funds for the advancing of the work of this department have usually been limited, the reports and bulletins mentioned are printed in limited editions many of which are now entirely exhausted.

Copies of such publications are available for reference, however, in the offices of the Division of Mines, in the Ferry Building, San Francisco; State Building, Los Angeles; State Office Building, Sacramento; Redding; and Division of Oil and Gas at Santa Barbara, Santa Paula, Taft, Bakersfield, Coalinga. They may also be found in many public, private and technical libraries in California and other states and foreign countries.

A catalog of all publications from 1880 to 1917, giving a synopsis of their contents, is issued as Bulletin No. 77.

Publications in stock may be obtained postpaid by addressing the San Francisco, Los Angeles or Sacramento offices and enclosing the requisite amount.

Remittances of stamps in an amount not to exceed 26 cents, currency or coin will be accepted at sender's risk. Payment is preferred in the form of money orders.

Money orders should be made payable to the Division of Mines.

NOTE.—The Division of Mines frequently receives requests for some of the early Reports and Bulletins now out of print, and it will be appreciated if parties having such publications and wishing to dispose of them will advise this office.

Write for latest revised price list.

REPORTS

Asterisks (**) indicate the publication is out of print.

Publication	Price (including postage and sales tax)
**First Annual Report of the State Mineralogist, 1880, 43 pp. Henry G. Hanks	----
**Second Annual Report of the State Mineralogist, 1882, 514 pp., 4 illustrations, 1 map. Henry G. Hanks	----
**Third Annual Report of the State Mineralogist, 1883, 111 pp., 21 illustrations. Henry G. Hanks	----
**Fourth Annual Report of the State Mineralogist, 1884, 410 pp., 7 illustrations. Henry G. Hanks	----
**Fifth Annual Report of the State Mineralogist, 1885, 234 pp., 15 illustrations, 1 geological map. Henry G. Hanks	----
Sixth Annual Report of the State Mineralogist, Part I, 1886, 145 pp., 3 illustrations, 1 map. Henry G. Hanks—Price $0.75, sales tax $0.02	$0.77
Part II, 1887, 222 pp., 36 illustrations. William Irelan, Jr.—Price $0.75, sales tax $0.02	.77
**Seventh Annual Report of the State Mineralogist, 1887, 315 pp. William Irelan, Jr.	----
**Eighth Annual Report of the State Mineralogist, 1888, 948 pp., 122 illustrations. William Irelan, Jr.	----
**Ninth Annual Report of the State Mineralogist, 1889, 352 pp., 57 illustrations, 2 maps. William Irelan, Jr.	----
**Tenth Annual Report of the State Mineralogist, 1890, 983 pp., 179 illustrations, 10 maps. William Irelan, Jr.	----
Eleventh Report (First Biennial) of the State Mineralogist, for the two years ending September 15, 1892, 612 pp., 73 illustrations, 4 maps. William Irelan, Jr.—Price $1.50, sales tax $0.05	1.55
**Twelfth Report (Second Biennial) of the State Mineralogist, for the two years ending September 15, 1894, 541 pp., 101 illustrations, 5 maps. J. J. Crawford	----
**Thirteenth Report (Third Biennial) of the State Mineralogist, for the two years ending September 15, 1896, 726 pp., 93 illustrations, 1 map. J. J. Crawford	----
Chapters of the State Mineralogist's Report, XIV Biennial Period, 1913-1914, Fletcher Hamilton:	
**Mines and Mineral Resources, Amador, Calaveras and Tuolumne Counties, 172 pp., paper	----
Mines and Mineral Resources, Colusa, Glenn, Lake, Marin, Napa, Solano, Sonoma and Yolo Counties, 208 pp., paper—Price $0.75, sales tax $0.02	.77
**Mines and Mineral Resources, Del Norte, Humboldt and Mendocino Counties, 59 pp., paper	----
**Mines and Mineral Resources, Fresno, Kern, Kings, Madera, Mariposa, Merced, San Joaquin and Stanislaus Counties, 220 pp., paper	----
**Mines and Mineral Resources of Imperial and San Diego Counties, 113 pp., paper	----
**Mines and Mineral Resources, Shasta, Siskiyou and Trinity Counties, 180 pp., paper	----
**Fourteenth Report of the State Mineralogist, for the Biennial Period 1913-1914, Fletcher Hamilton, 1915: A General Report on the Mines and Mineral Resources of Amador, Calaveras, Tuolumne, Colusa, Glenn, Lake, Marin, Napa, Solano, Sonoma, Yolo, Del Norte, Humboldt, Mendocino, Fresno, Kern, Kings, Madera, Mariposa, Merced, San Joaquin, Stanislaus, San Diego, Imperial, Shasta, Siskiyou and Trinity Counties, 974 pp., 275 illustrations, cloth	----
Chapters of the State Mineralogist's Report, XV Biennial Period, 1915-1916, Fletcher Hamilton:	
**Mines and Mineral Resources, Alpine, Inyo and Mono Counties, 176 pp., paper	----
Mines and Mineral Resources, Butte, Lassen, Modoc, Sutter and Tehama Counties, 91 pp., paper—Price $0.75, sales tax $0.02	.77

REPORTS—Continued

Asterisks (**) indicate the publication is out of print.	Price (including postage and sales tax)
Mines and Mineral Resources, El Dorado, Placer, Sacramento and Yuba Counties, 198 pp., paper — Price $0.75, sales tax $0.02	$0.77
Mines and Mineral Resources, Monterey, San Benito, San Luis Obispo, Santa Barbara and Ventura Counties, 183 pp., paper — Price $0.75, sales tax $0.02	.77
**Mines and Mineral Resources, Los Angeles, Orange and Riverside Counties, 136 pp., paper	----
**Mines and Mineral Resources, San Bernardino and Tulare Counties, 186 pp., paper	----
**Fifteenth Report of the State Mineralogist, for the Biennial Period 1915-1916, Fletcher Hamilton, 1917: A General Report on the Mines and Mineral Resources of Alpine, Inyo, Mono, Butte, Lassen, Modoc, Sutter, Tehama, Placer, Sacramento, Yuba, Los Angeles, Orange, Riverside, San Benito, San Luis Obispo, Santa Barbara, Ventura, San Bernardino and Tulare Counties, 990 pp., 413 illustrations, cloth	----
Chapters of the State Mineralogist's Report XVI, Biennial Period, 1917-1918, Fletcher Hamilton:	
Mines and Mineral Resources of Nevada County, 270 pp., paper — Price $1.00, sales tax $0.03	1.03
Mines and Mineral Resources of Plumas County, 188 pp., paper — Price $0.75, sales tax $0.02	.77
Mines and Mineral Resources of Sierra County, 144 pp., paper — Price $0.75, sales tax $0.02	.77
Seventeenth Report of the State Mineralogist, 1920, 'Mining in California during 1920,' Fletcher Hamilton; 562 pp., 71 illustrations, cloth — Price $2.50, sales tax $0.08	2.58
Eighteenth Report of the State Mineralogist, 1922, 'Mining in California,' Fletcher Hamilton. Chapters published monthly beginning with January, 1922:	
**January, **February, March, April, **May, June, July, August, September, October, **November, December, 1922	------
Chapters of Nineteenth Report of the State Mineralogist, 'Mining in California,' Fletcher Hamilton and Lloyd L. Root. January, February, March, September, 1923 — Price $0.40, sales tax $0.01	.41
Chapters of Twentieth Report of the State Mineralogist, 'Mining in California,' Lloyd L. Root. Published quarterly. January, April, July, October, 1924, per copy — Price $0.40, sales tax $0.01	.41
Chapters of Twenty-first Report of the State Mineralogist, 'Mining in California,' Lloyd L. Root. Published quarterly:	
January, 1925, Mines and Mineral Resources of Sacramento, Monterey and Orange Counties — Price $0.40, sales tax $0.01	.41
April, 1925, Mines and Mineral Resources of Calaveras, Merced, San Joaquin, Stanislaus and Ventura Counties — Price $0.40, sales tax $0.01	.41
July, 1925, Mines and Mineral Resources of Del Norte, Humboldt and San Diego Counties — Price $0.40, sales tax $0.01	.41
**October, 1925, Mines and Mineral Resources of Siskiyou, San Luis Obispo and Santa Barbara Counties	----
Chapters of Twenty-second Report of the State Mineralogist, 'Mining in California,' Lloyd L. Root. Published quarterly:	
**January, 1926, Mines and Mineral Resources of Trinity and Santa Cruz Counties	----
April, 1926, Mines and Mineral Resources of Shasta, San Benito and Imperial Counties — Price $0.40, sales tax $0.01	.41
July, 1926, Mines and Mineral Resources of Marin and Sonoma Counties — Price $0.40, sales tax $0.01	.41
**October, 1926, Mines and Mineral Resources of El Dorado and Inyo Counties, also report on Minaret District, Madera County	----
Chapters of Twenty-third Report of the State Mineralogist, 'Mining in California,' Lloyd L. Root. Published quarterly:	

REPORTS—Continued

Asterisks (**) indicate the publication is out of print.	Price (including postage and sales tax)
January, 1927, Mines and Mineral Resources of Contra Costa County; Santa Catalina Island——Price $0.40, sales tax $0.01	$0.41
April, 1927, Mines and Mineral Resources of Amador and Solano Counties Price $0.40, sales tax $0.01	.41
**July, 1927, Mines and Mineral Resources of Placer and Los Angeles Counties	--
October, 1927, Mines and Mineral Resources of Mono County Price $0.40, sales tax $0.01	.41
Chapters of Twenty-fourth Report of the State Mineralogist, 'Mining in California,' Lloyd L. Root. Published quarterly:	
January, 1928, Mines and Mineral Resources of Tuolumne County Price $0.40, sales tax $0.01	.41
April, 1928, Mines and Mineral Resources of Mariposa County Price $0.40, sales tax $0.01	.41
**July, 1928, Mines and Mineral Resources of Butte and Tehama Counties	----
October, 1928, Mines and Mineral Resources of Plumas and Madera Counties——Price $0.40, sales tax $0.01	.41
Chapters of Twenty-fifth Report of the State Mineralogist, 'Mining in California,' Walter W. Bradley. Published quarterly:	
January, 1929, Mines and Mineral Resources of Lassen, Modoc and Kern Counties; also on Special Placer Machines Price $0.40, sales tax $0.01	.41
**April, 1929, Mines and Mineral Resources of Sierra, Napa, San Francisco and San Mateo Counties	----
July, 1929, Mines and Mineral Resources of Colusa, Fresno and Lake Counties——Price $0.40, sales tax $0.01	.41
October, 1929, Mines and Mineral Resources of Glenn, Alameda, Mendocino and Riverside Counties——Price $0.40, sales tax $0.01	.41
Chapters of Twenty-sixth Report of the State Mineralogist, 'Mining in California,' Walter W. Bradley. Published quarterly:	
January, 1930, Mines and Mineral Resources of Santa Clara County; also Barite in California——Price $0.40, sales tax $0.01	.41
**April, 1930, Mines and Mineral Resources of Nevada County; also Mineral Paint Materials in California	----
**July, 1930, Mines and Mineral Resources of Yuba and San Bernardino Counties; also Commercial Grinding Plants in California	----
October, 1930, Mines and Mineral Resources of Butte, Kings and Tulare Counties; also Geology of Southwestern Mono County (Preliminary) Price $0.40, sales tax $0.01	.41
Chapters of Twenty-seventh Report of the State Mineralogist, 'Mining in California,' Walter W. Bradley. Published quarterly:	
January, 1931. Preliminary Report of Economic Geology of the Shasta Quadrangle. Beryllium and Beryl. The New Tariff and Nonmetallic Products. Crystalline Talc. Decorative Effects in Concrete Price $0.40, sales tax $0.01	.41
April, 1931, Stratigraphy of the Kreyenhagen Shale. Diatoms and Silicoflagellates of the Kreyenhagen Shale. Foraminifera of the Kreyenhagen Shale. Geology of Santa Cruz Island Price $0.40, sales tax $0.01	.41
**July, 1931. (Yuba, San Bernardino.) Feldspar, Silica, Andalusite and Cyanite Deposits of California. Note on a Deposit of Andalusite in Mono County; its occurrence and chemical importance. Bill creating Trinity and Klamath River Fish and Game District and its effect upon mining	----
October, 1931. (Alpine.) Geology of the San Jacinto Quadrangle south of San Gorgonio Pass, California. Notes on Mining Activities in Inyo and Mono Counties in July, 1931——Price $0.40, sales tax $0.01	.41
Chapters of Twenty-eighth Report of the State Mineralogist, 'Mining in California,' Walter W. Bradley. Published quarterly:	
January, 1932, Economic Mineral Deposits of the San Jacinto Quadrangle. Geology and Physical Properties of Building Stone from Car-	

REPORTS—Continued

Asterisks (**) indicate the publication is out of print. Price (including postage and sales tax)

mel Valley. Contributions to the Study of Sediments. Sediments of Monterey Bay. Sanbornite____________Price $0.40, sales tax $0.01	$0.41
**April, 1932. Elementary Placer Mining Methods and Gold Saving Devices. The Pan, Rocker and Sluice Box. Prospecting for Vein Deposits. Bibliography of Placer Mining__________________________	----
Abstract from April quarterly: Elementary Placer Mining Methods and Gold Saving Devices. Types of Deposits, Simple Equipment. Special Machines. Dry Washing. Black Sand Treatment. Marketing of Products. Placer Mining Areas. Laws. Prospecting for Quartz Veins. Bibliography (mimeographed)__Price $0.25, sales tax $0.01	.26
July-October. (Ventura.) Report accompanying Geologic Map of Northern Sierra Nevada. Fossil Plants in Auriferous Gravels of the Sierra Nevada. Glacial and Associated Stream Deposits of the Sierra Nevada. Jurassic and Cretaceous Divisions in the Knoxville-Shasta Succession of California. Geology of a part of the Panamint Range. Economic Report of a Part of the Panamint Range. Acquiring Mining Claims Through Tax Title. The Biennial Report of State Mineralogist ____________________________Price $0.75, sales tax $0.02	.77
Chapters of Report XXIX, 1933 (quarterly): titled 'California Journal of Mines and Geology,' containing the following:	
January-April. Gold Deposits of the Redding and Weaverville Quadrangles. Geologic Formations of the Redding-Weaverville District, Northern California. Geology of Portions of Del Norte and Siskiyou Counties. Applications of Geology to Civil Engineering. The Lakes of California. Discovery of Piedmontite in the Sierra Nevada. Tracing 'Buried River' Channel Deposits by Geomagnetic Methods. Geologic Map of Redding-Weaverville District, showing gold mines and prospects. Geologic map showing various mines and prospects of part of Del Norte and Siskiyou Counties________________________ Price $1.00, sales tax $0.03	1.03
July-October. Gold Resources of Kern County. Limestone Deposits of the San Francisco Region. Limestone Weathering and Plant Associations of the San Francisco Region. Booming, Death Valley National Monument, California. Placer Mining Districts, Senate Bill 480. Navigable Waters, Assembly Bill 1543_________________ Price $1.00, sales tax $0.03	1.03
Chapters of Report XXX, 1934 (quarterly): titled 'California Journal of Mines and Geology,' containing the following:	
January. Resurrection of Early Surfaces in the Sierra Nevada. Geology and Mineral Resources of Northeastern Madera County. Geology and Mineral Deposits of Laurel and Convict Basins, Southwestern Mono County. Notes on Sampling as Applied to Gold Quartz Deposits___ Price $0.60, sales tax $0.02	.62
April-July. Elementary Placer Mining in California and Notes on the Milling of Gold Ores_________________Price $1.00, sales tax $0.03	1.03
October. Current Mining Developments in Northern California. Current Mining Activity in Southern California. Geology and Mineral Resources of the Julian District, San Diego County. Geology and Mineral Resources of Elizabeth Lake Quadrangle. Dry Placers of Northern Mojave Desert. Biennial Report of State Mineralogist. Assessment Work Within Withdrawn Areas_____________________ Price $0.60, sales tax $0.02	.62
Chapters of Report XXI, 1935 (quarterly): titled 'California Journal of Mines and Geology,' containing the following:	
January. Review of Gold Mining in East-Central, 1934. Current Mining Activities in the San Francisco District with Special Reference to Gold. Geological Investigation of the Clays of Riverside and Orange Counties, Southern California. Information regarding Mining Loans by the Reconstruction Finance Corporation_____________ Price $0.60, sales tax $0.02	.62

REPORTS—Continued

Asterisks (**) indicate the publication is out of print. — Price (including postage and sales tax)

April. A Geologic Section Across the Southern Peninsular Range of California. New Technique Applicable to the Study of Placers. Grubstake Permits ------------------Price $0.60, sales tax $0.02 $0.62

July. Mines and Mineral Resources of Siskiyou County (with map). Dams for Hydraulic Mining Debris. Leasing System as Applied to Metal Mining. Mine Financing in California. New Laws Make Radical Change in Mining Rights------Price $0.60, sales tax $0.02 .62

October. Mines and Mineral Resources of San Luis Obispo County. Mineral Resources of Portions of Monterey and Kings Counties. Mining Activity at Soledad Mountain and Middle Buttes—Mojave District, Kern County. Geology of a Portion of the Perris Block, Southern California. Mineral Resources of a Portion of the Perris Block, Riverside County ----------------------Price $0.60, sales tax $0.02 .62

Chapters of Report XXXII, 1936 (quarterly): titled 'California Journal of Mines and Geology,' containing the following:

January. Gold Mines of Placer County, including Drag-line Dredges. Geologic Report on Borax Lake, California------------------------ Price $0.60, sales tax $0.02 .62

April. Geology, Mining and Processing of Diatomite at Lompoc, Santa Barbara County. Essentials in Developing and Financing a Prospect into a Mine. Gold-bearing Veins of Meadow Lake District, Nevada County. Semi-Precious Gem Stone Collection in Division Museum-- Price $0.60, sales tax $0.02 .62

July. Mines and Mineral Resources of Calaveras County. Mining in California by Power Shovel. Assessment Work on Mining Claims Within Withdrawn Areas. Joshua Tree National Monument. Cost of Producing Quicksilver at a California Mine in 1931-1932. The Age of Mineral Utilization-------------Price $0.60, sales tax $0.02 .62

October. Mineral Resources of Lassen and Modoc Counties. Mechanics of Lone Mountain Landslides, San Francisco. Biennial Report of the State Mineralogist, Properties and Industrial Applications of Opaline Silica ------------------------------Price $0.60, sales tax $0.02 .62

Chapters of Report XXXIII, 1937 (quarterly): titled 'California Journal of Mines and Geology,' containing the following:

January. Source Data of the Geologic Map of California, January, 1937. The Geology of Quicksilver Ore Deposits. Prospecting for Lode Gold -------------------------------Price $0.60, sales tax $0.02 .62

April. Mineral Resources of Plumas County (with Geologic Map). List of preferred mineral names. New Placer Mining Debris Law Price $0.60, sales tax $0.02 .62

July. Mineral Resources of Los Angeles County (with map showing principal Mines and Oil Fields.) Geology and mineral deposits of the Western San Gabriel Mountains, Los Angeles County---------- Price $0.60, sales tax $0.02 .62

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Minaret—Price $0.25, sales tax $0.01	.26
Perris Block Geologic—Price $0.25, sales tax $0.01	.26
Plumas County Geologic—Price $0.25, sales tax $0.01	.26
Shasta County Geologic—Price $0.25, sales tax $0.01	.26
El Dorado County—Price $0.25, sales tax $0.01	.26

OIL FIELD MAPS

The maps are revised from time to time as development work advances and ownerships change.

Map No. 1—Sargent, Santa Clara County—Price $0.75, sales tax $0.02	$0.77
Map No. 2—Santa Maria, including Cat Canyon and Los Alamos—Price $1.25, sales tax $0.04	1.29

OIL FIELD MAPS—Continued

The maps are revised from time to time as development work advances and ownerships change.

	Price (including postage and sales tax)
Map No. 3—Santa Maria, including Casmalia and Lompoc — Price $1.25, sales tax $0.04	$1.29
Map No. 4—Brea Olinda and (East Portion) Coyote Hills, Los Angeles and Orange Counties — Price $1.25, sales tax $0.04	1.29
Map No. 6—Salt Lake-Beverly Hills, Los Angeles County — Price $1.25, sales tax $0.04	1.29
Map No. 7—Sunset and San Emidio, Kern County — Price $1.25, sales tax $0.04	1.29
Map No. 8—South Midway and Buena Vista Hills, Kern County — Price $1.25, sales tax $0.04	1.29
Map No. 9—North Midway and McKittrick, Kern County — Price $1.25, sales tax $0.04	1.29
Map No. 10—Belridge and McKittrick Front, Kern County — Price $1.25, sales tax $0.04	1.29
Map No. 11—Lost Hills and North Belridge, Kern County — Price $1.25, sales tax $0.04	1.29
Map No. 12—Devils Den, Kern County — Price $1.00, sales tax $0.03	1.03
Map No. 13—Kern River, Kern County — Price $1.00, sales tax $0.03	1.03
Map No. 14—Coalinga and E. Coalinga Extension, Fresno County — Price $1.50, sales tax $0.05	1.55
Map No. 15—Elk Hills, Kern County — Price $1.25, sales tax $0.04	1.29
Map No. 16—Ventura-Ojai, Ventura County — Price $1.25, sales tax $0.04	1.29
Map No. 17—Santa Paula-Sespe, including Bardsdale, South Mountain and Camarillo, Ventura County — Price $1.25, sales tax $0.04	1.29
Map No. 18—Piru-Simi-Newhall, Ventura County — Price $1.25, sales tax $0.04	1.29
Map No. 19—Arroyo Grande, San Luis Obispo County — Price $1.00, sales tax $0.03	1.03
Map No. 20—Long Beach, Los Angeles County — Price $1.75, sales tax $0.05	1.80
Map No. 21-B—Portion of District No. 5, showing boundaries of oil fields—Fresno, Kings and Kern Counties — Price $1.00, sales tax $0.03	1.03
Map No. 21-C—Portion of District No. 4, showing boundaries of oil fields—Kern, Kings and Tulare Counties — Price $1.25, sales tax $0.04	1.29
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Map No. 26—Huntington Beach, Orange County — Price $1.50, sales tax $0.05	1.55
Map No. 27—Santa Fe Springs, Los Angeles County — Price $1.25, sales tax $0.04	1.29
Map No. 28—Torrance, Los Angeles County — Price $1.25, sales tax $0.04	1.29
Map No. 29—Dominguez, Los Angeles County — Price $1.00, sales tax $0.03	1.03
Map No. 30—Rosecrans, Los Angeles County — Price $1.25, sales tax $0.04	1.29
Map No. 31—Inglewood, Los Angeles County — Price $1.25, sales tax $0.04	1.29
Map No. 32—Seal Beach, Los Angeles and Orange Counties — Price $1.25, sales tax $0.04	1.29
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Map No. 34—Mt. Poso and Poso Creek, Kern County — Price $1.00, sales tax $0.03	1.03
Map No. 35—Round Mountain, Kern County — Price $1.00, sales tax $0.03	1.03

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OIL FIELD MAPS—Continued

The maps are revised from time to time as development work advances and ownerships change.

Map	Price (including postage and sales tax)
Map No. 36—Kettleman Hills, Fresno, Kings and Kern Counties — Price $1.50, sales tax $0.05	$1.55
Map No. 37—Montebello, Los Angeles County — Price $1.00, sales tax $0.03	1.03
Map No. 38—Whittier, Los Angeles County — Price $1.25, sales tax $0.04	1.29
Map No. 39—West Coyote, Los Angeles and Orange Counties — Price $1.25, sales tax $0.04	1.29
Map No. 40—Elwood, Santa Barbara County, and La Goleta, Santa Barbara County — Price $1.25, sales tax $0.04	1.29
Map No. 41—Potrero, Los Angeles County — Price $1.00, sales tax $0.03	1.03
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Map No. 53—Rio Bravo, Greeley, Kern County — Price $1.25, sales tax $0.04	1.29
Map No. 54—Wasco Oil Field, Buttonwillow and Semitropic Gas Fields, Kern County — Price $1.25, sales tax $0.04	1.29
Map No. 55—Canal, Canfield Ranch, Coles Levee, Strand, and Ten Section, Kern County — Price $1.25, sales tax $0.04	1.29
Map No. 56—Paloma, Kern County — Price $1.25, sales tax $0.04	1.29

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STATE OF CALIFORNIA
DEPARTMENT OF NATURAL RESOURCES
RICHARD SACHSE, Director

DIVISION OF MINES
FERRY BUILDING, SAN FRANCISCO

WALTER W. BRADLEY — State Mineralogist

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QUARTERLY CHAPTER

OF

STATE MINERALOGIST'S REPORT XXXVI

STATE DIVISION OF MINES
FERRY BUILDING, SAN FRANCISCO
CALIFORNIA

90678

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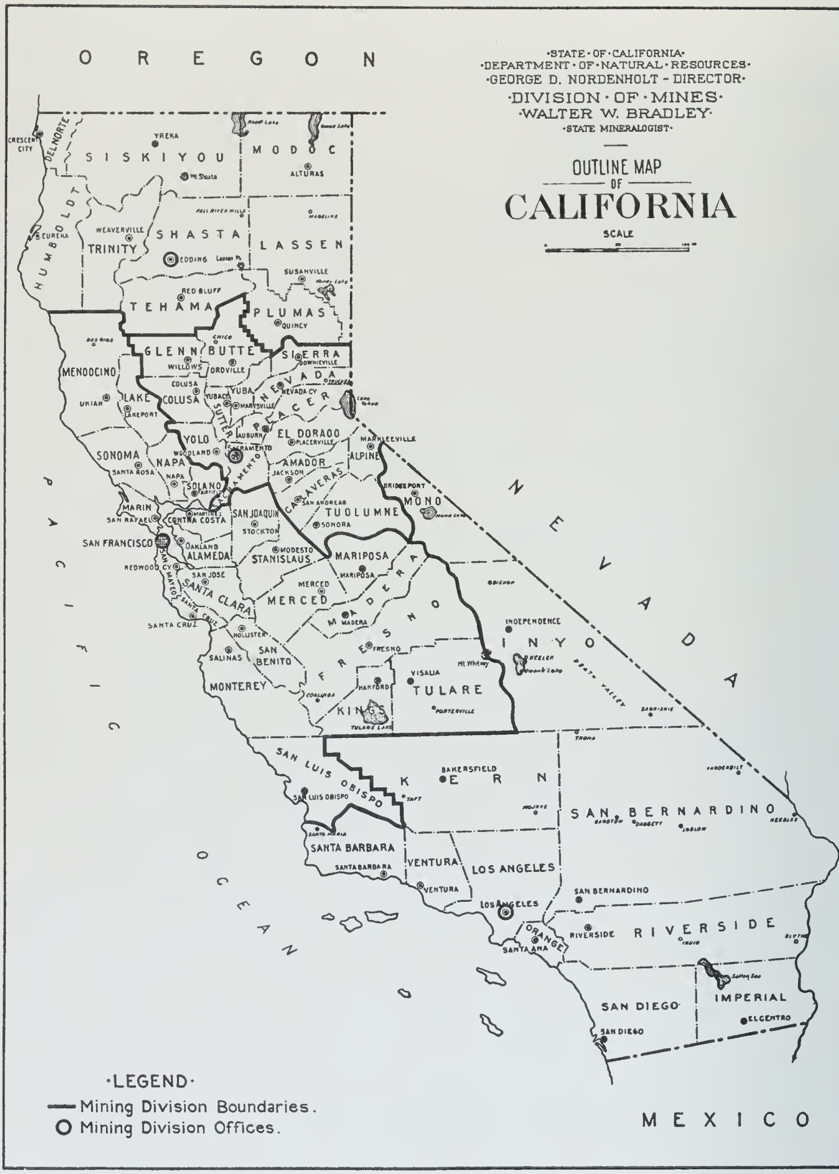

·STATE·OF·CALIFORNIA·
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·GEORGE D. NORDENHOLT – DIRECTOR·
·DIVISION·OF·MINES·
·WALTER W. BRADLEY·
·STATE MINERALOGIST·
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Mining Division Boundaries.
Mining Division Offices.

PREFACE

The Division of Mines (formerly State Mining Bureau) is maintained for the purpose of assisting in all possible ways in the development of California's mineral resources.

As one means of offering tangible service to the mining public, the State Mineralogist for many years has issued an annual or a biennial report reviewing in detail the mines and mineral deposits of the various counties.

As a progressive step in advancing the interests of the mineral industry, and as permitting earlier distribution to the public, publication of the Annual Report of the State Mineralogist in the form of monthly chapters was begun in January, 1922, and continued until March, 1923. Owing to a lack of funds for printing this was changed to a quarterly publication, beginning in September, 1923. For the same reason, beginning with the January, 1924, issue, it became necessary to charge a subscription price. This covers approximately the cost of printing.

Pages are numbered consecutively throughout the year and an index to the complete report is included annually in the closing number.

Beginning with the 1930 issues, the activities and progress of the Geologic Branch are recorded also in these quarterly chapters. The important part that geology plays in the economic development of our mineral resources is further recognized in the change of title from *Mining in California* to California Journal of Mines and Geology, beginning with the January, 1933, chapter.

While current activities of all descriptions are covered in these chapters, the practice of issuing from time to time technical reports on special subjects will be continued as well. A list of such reports now available is appended hereto, and the names of new bulletins will be added in the future as they are completed.

The chapters are subject to revision, correction and improvement. Constructive suggestions from the mining public will be gladly received, and are invited.

The one aim of the Division of Mines is to increase its usefulness and to stimulate the intelligent development of the wonderful, latent resources of the State of California.

Types of Reports

In general the reports presented in these chapters are grouped into three classes:

1. Mines and mineral resources of a given county or area (describing kind, character, distribution and extent of development).

2. Specific economic and industrial mineral products (listing and describing the resources over the entire state of a given mineral substance, e.g., feldspar).

3. Geological reports on specific areas (recording results and conclusions with maps, derived from field studies; and tied in with economic possibilities and developments).

REPORTS OF DISTRICT MINING ENGINEERS

In 1919–1920 the Mining Bureau was organized into four main geographic divisions, with the field work delegated to a mining engineer in each district, working out from field offices that were established in Redding, Auburn, San Francisco and Los Angeles, respectively. This move brought the office into closer personal contact with operators, and it has many advantages over former methods of conducting field work, including lower traveling-expense bills for the Bureau's engineers. In 1923 the Redding and Auburn field offices were consolidated and moved to Sacramento.

The Redding office was reestablished in 1928, and the boundaries of each district adjusted. The counties now included in each of the four divisions and the location of the branch offices are shown on the accompanying outline map of the state. (Frontispiece.)

Reports of mining activities and development in each district, prepared by the District Engineer, will continue to appear under the proper field division heading.

REDDING FIELD DISTRICT

Chas. Volney Averill, Mining Engineer

There is no report from the Redding Field District on account of unfinished field work.

SACRAMENTO FIELD DISTRICT

C. A. Logan, Mining Engineer

On account of unfinished field work, there is no report from the Sacramento Field District in this issue.

SAN FRANCISCO FIELD DISTRICT

C. McK. Laizure, Mining Engineer

Reports covering the mines and mineral resources of all of the counties in the San Francisco Field District are now available, and field work at present is confined to investigations for special reports upon various economic minerals.

LOS ANGELES FIELD DISTRICT

ECONOMIC MINERAL DEPOSITS OF THE NEWBERRY AND ORD MOUNTAINS, SAN BERNARDINO COUNTY

By W. B. Tucker, District Mining Engineer and
R. J. Sampson, Assistant Mining Engineer

The principal gold deposits associated with copper ores are located in the Ord Mountain District, in the Newberry Mountains and in the Stedman District, in the Bullion Mountains.

The productive mines in the Stedman District have been the Bagdad-Chase, Roosevelt Cons. Mines and the Lee Yim-Wheelock; the Ord Mountain Copper Mine in the Ord Mountains.

The gold deposits not associated with copper ores, occur in the East and West Ord Mountains and in the Fry Mountains, south of East Ord Mountain.

The principal deposits of silver and lead are in the Lava Bed District, in the Lava Bed Mountains and in the Calico Mining District, in the Calico Mountains.

GOLD

Bagdad-Chase Mine (Pacific Mines). The property comprises 17 patented mining claims, totaling 340 acres, situated in the Stedman Mining District, in Sec. 5, 6 and 8, T. 6 N., R. 8 E. S. B. M., 7 miles south of Ludlow; owner, John H. Hobbs, Glendora, Calif.

The mine was discovered in 1903 and was operated from 1904 to 1910 by the Bagdad-Chase Gold Mining Co. Ore was hauled from the mine to Barstow where 150,000 tons of ore was treated in a cyanide plant but due to the presence of copper carbonates and silicates in the ore, the recovery was only about 55%, resulting in a tailings' loss of $5 per ton in gold. The total production of gold during period of 1904 to 1910 was $4,500,000. From 1910 to 1916, the property was owned and operated by *Pacific Mines Corp.,* of New York. This company shipped 120,000 tons of copper-gold ore, with a gross value of $1,500,000 to the smelter at Clarkdale, Arizona. The average grade of the ore mined and shipped was 0.35 oz. in gold, 1.5 oz. in silver and 1.82% in copper. The last operations on the property were by *D'Aix Syndicate,* of Chicago, Ill., who operated the mine from March, 1938 to March, 1939, during which period 850 tons of ore was shipped to smelters in Arizona. The ore shipped is stated to have averaged $9.80 per ton in gold, with $.85 per ton in silver and .89% in copper. The total production has been $6,013,000.

The ore is deposited in an igneous breccia on contact of monzonite and rhyolite. The brecciated material which is the result of faulting, consists of both rhyolite and monzonite fragments, cemented with a highly siliceous material. The strike of the mineralized zone is E.-W. and dips 25° to 30° to the N. The footwall is monzonite with a rhyolite hanging wall. The orebody has been faulted by a series of faults which strike north and south, with displacements varying from 100 ft. to 240 ft. The ore is principally oxides of copper, some sili-

cates and very finely divided gold. The gangue is very siliceous and heavily stained with iron oxides.

Development consists of a vertical shaft 400 ft. deep and incline shaft 450 ft. deep, on 30° incline, with several thousand feet of drifts and crosscuts. It is reported that there is 20,000 to 30,000 tons of ore yet remaining in the mine with an average copper content of 1.5% and from $7 to $9 in gold and silver per ton.

Mine equipment consists of 2-cylinder, 125-h.p. diesel engine; 10 in. by 10 in. Sullivan compressor; 25-h.p. single drum hoist.

Under lease to Frank W. Royer, Red Mountain, Calif. Ore is being shipped to Arizona smelter. Five men are employed.

Bibl.: State Mineralogist's Reports XV, p. 790; XVII, pp. 341-342; XXVII, pp. 278-279; XXXVI, pp. 56-57.

Bullion Range Mine, comprising 31 claims, 12 of which are placer locations, adjoins the Bagdad-Chase Mine on the west, some 9 miles south of Ludlow; owner, Bullion Range Co., Inc., Roger Dering, president, Ludlow, Calif.

These claims are, presumably, located on the extension of the Bagdad-Chase vein system. The vein strikes N. 25° W., dips N. 65° E. The operators say that the hanging wall rock has been determined a trachyte. Footwall is monzonite. The average width between walls is about 12 ft.

Development consists of 120-ft. shaft on 32° inclination. At 100 ft., a drift on the barren contact was driven N. 25° W. 200 ft. At 60 ft. from the shaft, a winze was sunk 100 ft. and drifts from the bottom driven 80 ft. southeast and 125 ft. northwest, all of this work being on the contact of the volcanic hanging wall and the monzonite footwall. At 85 ft. from the winze in the northwest drift, an east-west fault was encountered (dip 85° N.). Also here is a vein filled with recemented breccia. A winze has been sunk on this vein to 130 ft.; still sinking.

A crew of about 12 men is employed.

Camp Rock Mine (placer). It consists of 3 lode claims and 9 placer claims in Sec. 28, T. 7 N., R. 3 E., S. B. M., in the Bessemer Mountains, 25 miles northeast of Box S Ranch and 47 miles (by road) from Victorville; owner, S. H. Clinedinst, Pasadena, Calif.; elevation 4500 ft.

The claims lie on the detrital slope at the foot of the southwest side of the Bessemer Mountains. The drainage is to the southwest into the valley which also receives the drainage from the southwest slope of the Ord Mountains. A narrow drainage channel on this slope has been prospected for about 1000 ft. The work consists of shallow pits and opencuts. The general course of channel is northeast-southwest; its width being about 600 ft., with depth of gravel varying from 2 ft. to 25 ft. Bedrock is granite. Values range from 25¢ to $1.25 per cu. yd. The deposit has been worked by dry washers previous to 1932. In 1932, a washing and screening plant was installed on the property and operated until September, 1933. Water for operating this plant was secured from two wells located one-quarter of a mile west of the deposit. One well has a depth of 200 ft., the other 250 ft. Idle.

Bibl.: State Mineralogist's Report XXVII, p. 291.

Claw Hammer Mine (copper-gold). It comprises 4 claims, in the Belleville Mining District, in the Ord Mountains, 6 miles southeast of Daggett; owner, Jens Youngreen Estate, Los Angeles.

Mineralization: Copper oxides occur along fractures in quartz monzonite near its contact with rhyolite. Strike of belt is NE.-SW.; dip 70° to the E. Width varies from 4 ft. to 12 ft.

Bibl.: State Mineralogist's Report XXVII, p. 267.

Cumberland Mine. It comprises 7 claims located in the Ord Mountain Mining District, on the west slope of the Fry Mountains, in Sec. 25 and 26, T. 6 N., R. 2 E., S. B. M., 17 miles northeast of Lucerne, and 35 miles east of Victorville; elevation 3500 ft.; owners, Harry Fredericks and Hugh Connell, Alhambra, Calif.

A quartz vein occurs in granite known as the Cumberland-Vulture vein; strikes N.-S. and dips 85° W.; width 18 in. to 3 ft. Development consists of six shafts sunk on vein to depths of 50 ft. to 137 ft. On the Cumberland Claim, the north shaft is 75 ft. in depth. About 175 ft. south of this shaft, is a shaft sunk on the vein to a depth of 137 ft. On the 135-ft. level of the south shaft, there is a drift 100 ft. north and 50 ft. south. There are also two shafts on the Rambler Claim which is located south of Cumberland Mine. About 2000 ft. south of Rambler works are the Vulture and Roosevelt shafts. The vein quartz developed in these workings is mineralized with hematite, pyrite, marcasite and chalcopyrite. Idle.

Bibl.: State Mineralogist's Report XXXVI, p. 63.

Desert King Mine. It comprises 640 acres in Sec. 16, T. 10 N., R. 1 W., S. B. M., situated 6 miles northeast of Barstow; elevation 2600 ft.; owner, *Sacramento Land & Development Co.,* Forum Bldg., Sacramento, Calif. A subsidiary company has been organized by the members of the above corporation known as the *Desert King Mining Co.,* Frank Newbert, president; C. F. Doyle, secretary, Forum Bldg., Sacramento, Calif.

A mineralized zone 600 ft. in width and 3000 ft. in length occurs in Pre-Cambrian schist and gneiss. The strike of this zone is NE. and SW. and with a general dip of 40° NW. Development consists of a number of shallow trenches made across the mineralized zone. There are ten trenches from 100 ft. to 400 ft. in length, with a depth of 2 ft. On the northeast end of the property there is also an opencut 50 ft. in length and 15 ft. in depth. A tunnel has been driven southwest 56 ft. connecting with a shaft 50 ft. deep. On the west end of the property, there is a shaft 200 ft. in depth and a number of opencuts. The trenches have been systematically sampled by engineers of the company and it is reported that ore exposed in these trenches will carry from $1.25 to $5 per ton in gold. The gold occurs free, associated with hematite and pyrite. The company also sank a well on the property 517 ft. deep, with 10-in. casing. Water stands at 377 ft. The well is reported to make 40 gal. per minute. It is equipped with Peerless turbine engine, driven by gas engine. Capacity of pump is 100 gal. per minute. Storage tank has a capacity of 20,000 gal. Idle.

Bibl.: State Mineralogist's Report XXX, p. 324.

Dull Pick Mine. It comprises 3 claims situated in Stedman Mining District 9 miles south of Ludlow, a station on the Santa Fe Railroad; elevation 2500 ft.; owners, W. H. Brown and W. T. Russell, Ludlow, Calif.; under lease to H. J. Jackson and John Funk, Ludlow, Calif.

The vein occurs on contact of monzonite and dacite; strike E.-W., dip 35° N.; width of vein 4 ft. Vein is heavily iron-stained, brecciated porphyry. Values range from $6 to $8 per ton. Development consists of two incline shafts about 50 ft. apart, sunk on the vein to depths of 180 ft.

Equipment consists of 6-h.p. gas-driven hoist and 150 cu. ft. Ingersoll-Rand compressor. Ore from this property was hauled to the Jackson cyanide plant at Ludlow which had a capacity of 25 tons per 24 hours. Several hundred tons of ore was milled in this plant and the average value is reported to have been $8 per ton. Recovery made is reported to have been 93%. Idle.

Elsie Mine. It comprises one patented claim adjoining the Cumberland Mine on the southwest, in the Fry Mountains, in Ord Mining District, in Sec. 26, T. 6 N., R. 2 E., S. B. M., 17 miles northeast of Lucerne Valley P. O.; elevation 4000 ft.; owner, Mrs. Florence Gilbert, Colton, Calif.

The vein strikes N. 15° E., dips 85° W.; width 12 in. to 2 ft. The formation is granite. The vein quartz is mineralized with free gold, associated with pyrite. Development consists of a shaft sunk on the vein to a depth of 250 ft. and about 500 ft. south of this shaft, there is a shaft on the vein to a depth of 75 ft. About 100 ft. north of the main shaft, there is an andesite dike 10 ft. thick that intersects the vein. The dike strikes E. Ore shipped from the property by leasers is reported to have had an average value of $25 per ton in gold. Idle.

Ford Mine. It comprises 6 claims situated in Sec. 10, T. 6 N., R. 2 E., S. B. M., on the southeast slope of Ord Mountain; elevation 4300 ft., 18 miles northeast of Lucerne and 42 miles northeast of Victorville, Calif.; owner, Thomas Hodgkiss, Lucerne P. O., Calif.

A series of parallel, narrow veins strikes N. 30° E., dip 65° NW.; width 6 in. to 2 ft., in granite. Vein quartz carries free gold. Some samples are reported to carry from $50 to $90 per ton in gold. There is also a quartz vein in granite, 8 ft. in width; strike N. 60° E. Development consists of shafts 20 ft. to 40 ft. in depth on different outcrops. Idle.

Gem Placer Mine. It comprises 2 placer claims, situated in Sec. 10, T. 8 N., R. 1 E., S. B. M., 4 miles south of Daggett; elevation 3500 ft. The gold occurs in a fine state in erosion material. It has been prospected with dry washers. Idle.

Gold Belt Mine. This property comprises 9 claims, situated on the southwest slope of Goat Mountain, in Sec. 30, T. 7 N., R. 1 E., S. B. M., 38 miles northeast of Victorville; elevation 4500 ft.; owners, E. L. Mellville Estate, George Henderson and H. V. Bryant, Chula Vista, San Diego Co., Calif.

The country rock is granitic, largely monzonite and diorite. A fissure vein varying in width from 2 ft. to 7 ft., filled largely with quartz and calcite and in places, having a rhyolite casing on the hanging wall side, strikes N. 40° E., dips 45° SE. Mineralization consists of free gold, pyrite and chalcopyrite.

Development consists of vertical shaft 275 ft. deep which connects with the mill tunnel. Three levels were driven from this shaft at 50, 100 and 240-ft. horizons. On the 50-ft. level, there is a drift 50 ft. southwest and 100 ft. northeast, with a 50-ft. winze in the northeast drift; on the 100-ft. level, drift 50 ft. southwest and 40 ft. northeast; on the 240-ft. level, drift 75 ft. southwest and 700 northeast. At 208 ft. from shaft, there is a raise 50 ft. into the stope which is about 30 ft. long. The vein in this stope is 10 in. to 2½ ft. wide. At bottom of the shaft, the mill tunnel was driven northeast about 820 ft. and a 30-ft. raise driven to connect with shaft. At 550 ft. from portal, there is a 30-ft. raise; at 600 ft. from portal, a raise about 180 ft. to 100-ft. level; at 750 ft. from portal, a raise 270 ft. to surface which raise was used as an ore pass at each level; at 800 ft. from portal raise 30 ft. to the 240-ft. level.

In 1930 a 40-ton mill was installed on the property by the Gold Belt Mining Co., C. W. Fontaine, president and manager. The plant was operated until the latter part of 1932 when operations were suspended and all equipment removed from the mine. Idle.

Bibl.: State Mineralogist's Report XXVII, pp. 296-297.

Gold Peak Mine. It comprises 4 claims situated in the Fry Mountains, in Sec. 30, T. 6 N., R. 3 E., S. B. M., 18 miles northeast of Lucerne P. O.; elevation 5400 ft.; owner, R. E. Johnson, Victorville, Calif.

Four parallel veins occur in granite; strike N.-S., dip vertical. Width is 2 ft. to 4 ft. Development consists of shaft 120 ft. deep, with 200 ft. of drifts on 50-ft. level and 100-ft. levels. The vein quartz shows free gold associated with pyrite. The ore mined from the property was milled at Old Womans Springs by Johnson in 1906. Idle.

Gold Standard Group, comprising 7 claims, is in the Stedman Mining District, 3½ miles south of Ludlow, in Sec. 32, T. 7 N., R. 8 E., S. B. B. & M., adjoining the Yim-Wheelock (Old Pete) Mine on the west; elevation 2200 ft.; owners, Wm. Wheelock Estate, J. Dorn and Wm. Maher, Ludlow, Calif.

The outcrops on this property are rhyolite. A zone of fracturing in this rhyolite strikes NE.-SW., dip NW. It is filled with crushed country rock highly stained with the oxides of iron, copper and manganese. Pannings of this material show very fine gold. The width of this zone has not been determined. Assays are reported to run up to $35 in gold.

Development consists of a shaft sunk 70 ft. on 30° inclination, in the fractured zone. Southeast of this shaft 150 ft., is a vertical shaft 110 ft. deep. This shaft is reported to have struck a rhyolite-andesite contact. At 50 ft. a crosscut (?) was driven east 120 ft. (these workings inaccessible). Some 50 ft. east of the 70 ft. incline shaft, a vertical shaft was sunk to a depth of 100 ft., reportedly striking the contact at 80 ft. Idle.

Grand View Mine. It comprises 4 claims located on the southeast slope of Ord Mountain, in Sec. 10, T. 6 N., R. 2 E., S. B. M., 18 miles northeast of Lucerne and 42 miles northeast of Victorville; elevation 4100 ft.; owners, *Garvan Mining & Reduction Co.,* W. G. Van Horn Estate, Los Angeles.

A series of parallel veins which strike N. 30° E. and dip 65° NW., occurs in andesitic porphyry. The main development work has been confined to the Grand View vein which is exposed on the surface for a distance of 3000 ft. along its outcrop. The vein has a maximum width of 15 ft., with an average width of 8 ft. The footwall of the vein is a granitic porphyry, with an andesite hanging wall. The vein is brecciated rhyolitic-porphyry, highly silicified, iron-stained hematite, carrying free gold. Both north and south of the Grand View shaft are some intrusive dikes which strike north and south. East of the shaft there is also an intrusive diabase dike that probably faults the vein north of the shaft.

Development consists of a 2-compartment shaft sunk to a depth of 150 ft. on an incline of 65°. Some very high grade ore was extracted above the 40-ft. level. Below this level values decrease. On the 40-ft. level the vein was drifted on 75 ft. There are about 150 ft. of drifting on 100-ft. level. Idle.

Bibl.: State Mineralogist's Report XXVII, p. 299.

Hoover Mine. It comprises 10 claims situated on the southeast slope of Ord Mountain, in Sec. 10, T. 6 N., R. 2 E., S. B. M.; elevation 4400 ft.; eighteen miles northeast of Lucerne. Owner is Mrs. Souls, Barstow, Calif.; under lease to Thomas Hodgkiss, Lucerne P. O., Calif.

On Hoover No. 1 Claim, there is a rhyolite vein-dike 20 ft. to 50 ft. wide; strike N. 30° W., dip 70° NE., in granite. On Hoover No. 3 Claim, there is a series of northeast-southwest stringers in a porphyritic dike. The quartz veins vary from 6 in. to 2 ft. in width.

Development consists of a tunnel driven north 90 ft. with a drift 120 ft. west; also a shaft 50 ft. in depth.

Two men are employed on development work.

L and L Mines (copper-gold), comprise 17 claims located in Ord Mountain District, in Sec. 17, T. 7 N., R. 3 E., 9 miles southeast of Newberry Springs; owner, L & L Mining Co., O. A. Lau, Riverside, Calif.

A series of parallel veins occurs in monzonite. The veins strike NE.-SW., dip 50° SW. They vary in width from 12 in. to 2 ft. Quartz is mineralized with copper oxides of malachite and azurite; also bornite and chalcopyrite with gold and silver values.

Development consists of a shaft sunk on one of the veins to a depth of 50 ft.; also crosscut tunnel driven north 70° east, 500 ft. About 300 ft. east of the shaft is a quartz vein in monzonite, strike N. 10° E., dip 75° W.; width 12 in. to 2 ft. Idle.

Bibl.: State Mineralogist's Report XXVII, p. 274.

Ludlow Belle Mine. It comprises 2 claims known as Barite No. 1 and Barite No. 2, adjoining Markeson Mine, in the Stedman Mining District, 9 miles by road south of Ludlow; owner, Lowell Jorgenson,

Long Beach, Calif. It is leased to Jackson and Jordon, Ludlow, Calif. Elevation is 2500 ft.

The vein strikes E.-W., dip 35° N. and occurs on contact of monzonite and rhyolite. Width is 4 ft. to 6 ft. The vein material is heavily iron-stained rhyolitic porphyry. Gold occurs in a very fine state. Development consists of shaft 65 ft. in depth sunk on the vein and several opencuts. Idle.

Markeson Mine. It comprises one claim situated in Sec. 7, T. 6 N., R. 8 E., S. B. M., in Stedman Mining District, 9 miles by road south of Ludlow; elevation 2500 ft.; owner, Thomas N. Hall, Ludlow, Calif.

The vein occurs on contact with rhyolite and monzonite. Strike of vein is E. and W.; dip 40° N. The vein has a width of 4 ft. to 6 ft. The vein material is heavily iron-stained, brecciated porphyry. The principal values are in gold which occurs in a very fine state.

Development consists of opencuts and shafts. The main working shaft has been sunk on an inclination of 40° to a depth of 110 ft.; stoped from 40-ft. level to 100-ft. level. Ore shoot developed had a length of 60 ft. and an average width of 5 ft. Average value of the ore was $11.74 per ton in gold. Seven hundred tons of ore was mined and shipped to American Smelting & Refining Company's smelter at Garfield, Utah. Idle.

Maumee Placers. These placers are located in the Lava Bed Mining District in Sec. 1, T. 5 N., R. 5 E., S. B. M., 18 miles northeast of Old Woman Springs and 50 miles east of Victorville; elevation 3000 ft. The deposit was formerly owned and operated by J. E. Lewis, Big Pine, Calif. The gold occurs in a fine state in erosional material. Development consists of shafts and test pits in unassorted gravel wash. Idle.

Bibl.: State Mineralogist's Report XXX, p. 250.

Ord Belt Mine. It comprises 12 claims situated on the south slope of Ord Mountain, in Sec. 4 and 10, T. 6 N., R. 2 E., S. B. M., 21 miles east of Lucerne P. O.; owner, W. O. Raymond, Lucerne P. O., Calif.; elevation 5000 ft.

The rocks exposed on the property consist of monzonite, rhyolite, andesite and dacite. The rhyolite occurs both as a capping and in intrusive dikes. There are two systems of veins. The north-south veins occur in dacite, while the northeast-southwest veins occur at the contact of the rhyolite with monzonite. The veins vary in width from a few inches to 5 ft. The vein filling consists of quartz and brecciated wall-rock, cemented with quartz. Values are all in gold, both free and in the sulphides.

Development consists of tunnel driven south 40° west, 300 ft. to intersect east-west vein. Some 700 ft. northwest of tunnel, another tunnel is driven southwest 160 ft. on contact of rhyolite and monzonite. At about 200 ft. in elevation below the above mentioned workings, a crosscut tunnel has been driven west 500 ft. The strike of the contact of the rhyolite and monzonite is NE.-SW. and dips flatly west. The new work consists of a tunnel driven 75 ft. east, with a raise to

the surface and a tunnel driven west 200 ft., in the gulch south of crosscut. North of crosscut, a tunnel has been driven east 75 ft., with a 30-ft. raise to surface at the face. Idle.

Bibl.: State Mineralogist's Report XXVII, pp. 307-308.

Ord Mountain Mine (copper-gold). The property comprises 8 patented claims and 20 claims held by location, situated in the Ord Mountain District, in Sec. 19 and 20, T. 7 N., R. 2 E., S. B. M., 14 miles southeast of Daggett; elevation 4000 to 5500 ft.; owner, Frank A. Werner, Los Angeles; under option to Ray T. Savage, Barstow, Calif.

A series of roughly parallel veins occurs in andesite. The strike of the veins varies from N. 15° E. to N. 15° W. and dips vary from 50° to 70° to the east. Width of veins varies from 4 ft. to 20 ft. The mineralization for a depth of 125 ft. consists of copper carbonates and free gold. Below this depth, the primary sulphides, chalcopyrite and bornite, are the principal minerals and carry values in gold.

Development work consists of the Brilliant shaft sunk on an inclination of 70° to a depth of 200 ft., with levels at 100 ft. and 180 ft., with several hundred feet of drifts on these levels. The ore developed is reported to carry 3% copper, with an average gold value of $4.00 per ton. On the Belgium Claim, a tunnel has been driven southwest 480 ft. and at 140 ft. from portal, there is a winze 200 ft. deep. On the Josephine Claim is a tunnel driven southwest 500 ft. Ore developed in this tunnel has a width of 18 ft. On the Rio Vista Claim, there are two tunnels. The lower tunnel is a crosscut 770 ft. east. At 700 ft. from the portal cut the Rio Vista vein, with a drift 437 ft. south and 110 ft. north. At 125 ft. in elevation above lower tunnel, the upper tunnel is driven as a crosscut 250 ft. east, with drifts north and south on the vein. It is reported the average grade of the ore developed in the above-mentioned workings carries from $3 to $5 in gold per ton and from 2% to 3% copper. Idle.

Bibl.: State Mineralogist's Reports X, p. 528; XII, p. 234; XIII, p. 326; XV, p. 789; XXVII, pp. 276-278; Bull. 50, p. 336.

Painsville Mine (copper-gold). It comprises one patented claim, situated in Sec. 19, T. 7 N., R. 2 E., S. B. M., on the west slope of Ord Mountain, in the Ord Mountain Mining District, 14 miles south of Daggett; elevation 4500 ft.; owners, I. D. Garringer and J. C. MacMillan, Los Angeles.

The Rio Vista vein cuts across this claim, strike N. 20° W., dip 75° E. It occurs in andesite. Width of vein is 6 ft. to 10 ft. The dip of the contact of andesite and monzonite is 45° W. On the south end of the claim, there is a quartz vein which strikes N. 20° E. and this vein forms a junction with the Rio Vista vein about 250 ft. south of shaft. The width of the vein is 15 ft. and it is in monzonite. The vein quartz is mineralized with gold and copper oxides. Development consists of shaft 90 ft. deep and an open cut south of shaft. Idle.

Bibl.: State Mineralogist's Reports X, p. 528; XV, pp. 808-809; XVII, pp. 309-310.

Red Hills Mine, comprising 13 claims, is across the valley directly east of the Ord Belt Mine about 3 miles, and some 24 miles east of Lucerne; owner, W. A. Raymond, on the ground.

The country rock is monzonite in which there are rhyolite and diorite dikes. The vein which accompanies one of the rhyolite dikes, strikes N.-S., dips 55° E. and is from a few inches to 6 or 8 ft. in width. Spotted gold values occur in this vein. Their presence is indicated by vugs filled with quartz crystals.

Development consists of 60-ft. shaft on the vein and drift 70 ft. south and several open cuts. About 2000 ft. south of this shaft, there is a 40-ft. shaft and tunnel south 200 ft.

Idle except for assessment work.

Roosevelt Cons. Mines (see Bagdad-Chase Mine).

Yim-Wheelock Mine (Old Pete). It comprises 3 claims, totaling 60 acres in the Buckeye Mining District, in Sec. 33, T. 7 N., R. 8 E.,

Yim-Wheelock Mine, 4 miles south of Ludlow, San Bernardino County.

S. B. M., 4 miles south of Ludlow; elevation 2200 ft.; owners, Lee Yim, William Wheelock Estate, of Ludlow, Calif., and Ralph Swing, San Bernardino, Calif.; under lease to J. H. Miller, Ludlow, Calif.

The ore occurs in a brecciated dacite-porphyry on contact with monzonite. The mineralized zone is 30 ft. to 50 ft. in width and about 600 ft. in length. Strike is N. and S., dip 30° E. The average grade of ore shipped from the property was 0.81 oz. per ton in gold, with some shipments carrying 1.8 oz. per ton. Total production to date is $25,000 to $30,000.

Development consists of tunnel driven south 60 ft., about 10 ft. in elevation below open cut. Open cut is 50 ft. in length by 30 ft. in width and 40 ft. below outcrop. Tunnel driven west about 100 ft. from floor of glory hole; incline winze at north edge of glory hole about 60 ft. deep; also short tunnels and open cuts south of glory hole (open cut) at higher elevations.

Five men are employed taking ore from glory hole and shipping to Clarkdale, Ariz.

Bibl.: State Mineralogist's Report XXX, p. 326.

IRON DEPOSITS

A large deposit of iron ore occurs on Iron Ridge near Bessemer Basin, in the Lava Bed Mining District.

Iron Mountain Deposit. The deposit is in Sec. 27 and 28, T. 6 N., R. 4 E., S. B. M., about 18 miles southeast of Newberry, a station on the Santa Fe Railroad; elevation 3000 to 3880 ft. Holdings comprise 7 claims, totaling 140 acres; owners, Mrs. Phoebe Owens, San Francisco, and E. S. Lake, Los Angeles.

Two massive veins of hematite and magnetite ore occur on the ridge known as Iron Mountain which is the southeasterly prolongation of the Newberry Mountains. The veins of iron ore occur on contact of dolomite and granite. They strike N. 20° E., dip 30° NW. These veins are about 150 ft. apart and vary in width from 30 ft. to 400 ft.

The deposit is reported to contain 10,000,000 tons of commercial ore. Analysis of the ore is as follows: iron 65%; silica 5.5; sulphur .06%; phosphorus .045%.

Bibl.: State Mineralogist's Reports IX, p. 235; XV, p. 819; XXVII, p. 335; Bull. 38, pp. 299-300.

MANGANESE

Black Butte Manganese Mine. It comprises 6 claims situated in Sec. 10, T. 8 N., R. 6 E., S. B. M., 21 miles east of Newberry and 2 miles north of Pizgah, a siding on the Santa Fe Railroad; owner, C. S. Van Doran, Daggett, Calif.; under lease to *Pizgah Minerals, Inc.,* N. W. Clark, president; H. E. Wilcox, superintendent.

Manganese occurs along a fault in dacite which strikes N.-S. and dips 70° W. Width of ore is 4 ft. to 6 ft. Manganese oxides occur along the fault, intermixed with crushed wall-rock. Two tunnels have been driven north along fault fracture, a distance of 60 feet. The upper tunnel is 20 ft. above lower tunnel. Several carloads of ore were shipped from this deposit in 1918, reported to carry 40% manganese. The ore is pyrolusite and psilomelane.

Equipment consists of 300-cu. ft. compressor. Two men are employed on development.

Newberry Manganese Deposit. It comprises 4 claims situated on the north slope of Newberry Mountain, one mile south of Newberry Springs. Manganese oxides occur in rhyolite conglomerate along an east-west fault. Development work consists of shallow open cuts. The ore is pyrolusite and psilomelane. The ore occurs as stringers and narrow veins in shear zone along the east-west fault. Idle.

SILVER

Two important silver districts occur in the Newberry quadrangle. The most productive deposits have been in the Calico Mountains, with an output record of over $10,000,000 in silver. The other area of importance is in the Lava Bed District, in a small range of mountains known as the Little Wonder Ridge, being a part of the Newberry Mountains, extending in a northwest and southeast direction for many miles. The district is located southwest of Lavic, a station on the Santa Fe Railroad. The most important mines are located on the

Imperial Lode which can be traced on the surface in a bold outcrop for several miles. This fissure occurs in quartz porphyry and is from 4 ft. to 18 ft. in width. The strike of the lode is N. 70° W. and dips 70° W. A felsitic dike follows the fissure for a considerable distance.

Blackfoot Group of Mines. It comprises 7 claims adjoining the Calico Odessa Group of Mines on the east and on ridge east of Odessa Canyon, in the Calico Mining District, in Sec. 14, T. 10 N., R. 1 E., S. B. M., 5 miles northwest of Yermo, a station on the Union Pacific Railroad; owner, Mrs. J. R. Lane, Calico, Calif.; elevation 2600 ft.

The ore occurs in fractures and crushed zones of rhyolite. These zones are connected with a distinct fault plane, known as Golconda fault. The general course of this fault is northwest and southeast, with a dip of 50° SW. Some ore was found along the fault but the principal ore showings are southwest of the fault. The silver ores occur in cracks and seams in the rhyolite tuff. The argentiferous minerals are cerargyrite and embolite; in a gangue of barite.

Development consists of tunnel driven along the fault and some open cuts. Idle.

Alabama-Mountain View Group of Mines. It comprises 3 patented claims known as Alabama, Mountain View and Snow Bird, situated in the Calico Mining District, adjoining the Blackfoot Group on the south and on ridge north of Odessa Canyon, in Sec. 14 and 23, T. 10 N., R. 1 E., S. B. M., 5 miles northwest of Yermo, a station on the Union Pacific Railroad; elevation 2500 ft. The property was formerly owned by *Oro Grande Mining Co.*

Development consists of short tunnels and open cuts. Silver ore occurs in fractures and seams in brecciated rhyolite tuff. The silver minerals are cerargyrite and embolite. Idle.

Argentum Group of Mines. It comprises 3 patented claims, situated in the Calico Mining District, adjoining the Calico Odessa Group of Mines on the west and on ridge west of Odessa Canyon, in Sec. 10 and 15, T. 10 N., R. 1 E., S. B. M., 5 miles northwest of Yermo, a station on the Union Pacific Railroad; elevation 2700 ft.; owner, Henry W. Britt, Barstow, Calif.

This group of claims is located along the Bismark fault, being N. 17° W.; dip 30° W. Chlorides and chlorobromides occur in irregular fractures and joint planes in a rhyolite tuff along the Bismark fault fissure. Development consists of a number of open cuts and tunnels. Idle.

Burcham Mine (Total Wreck) (gold, silver-lead). The property comprises 21 unpatented claims, totaling 415 acres, situated in the Calico Mining District, on the south slope of the Calico Mountains, in Sec. 16 and 21, T. 10 N., R. 1 E., S. B. M., 5 miles northwest of Yermo, a station on the Union Pacific Railroad; elevation 1800 to 2850 ft.; owner, Dr. Rose L. Burcham, Alhambra, Calif. The property is under lease and bond to the Burcham Mines, Inc., H. S. Kimball, president; I. S. Betts, secretary; Granville Moore, consulting engineer and manager.

The property has been under development for the past two years to determine the extent and value of the orebodies developed along

the Burcham and the Mulcahy fault fractures. The mud shales and the argillacious sandstones here lie nearly horizontal and contact with tufaceous breccia or yellow-colored rhyolite on the northwest.

The Burcham vein strikes N. 70° W. and dips 65° S.; width 3 ft. to 10 ft. The minerals in this vein are gold, silver and lead. The gold is finely divided and disseminated throughout the quartz, with iron present as hematite and limonite. Lead occurs as lead carbonates, with occasional bunches of galena and sphalerite. Silver occurs as silver chloride. The Mulcahy vein is 500 ft. north of the Burcham and the principal values are in gold and silver. This vein strikes N. 45° W. and dips 65° S.; width 4 ft. to 30 ft. The high-grade streak formerly worked is on the footwall; width of 26 in., with mineralization extending into hanging wall for a width of 15 ft. to 30 ft. The ore developed on this vein is said to have an average value of $6.50 per ton in gold and silver.

Development consists of crosscut tunnel N. 15° E., 512 ft. in length. At 104 ft. from the portal, the Burcham vein was intersected, with drift on the vein 200 ft. southeast and 640 ft. northwest. Three winzes have been put down on Burcham vein to depths of 250 ft. from tunnel level, about 200 ft. apart. In this development work below tunnel level, bunches of sulphide ore were encountered, being galena associated with sphalerite. These ore deposits are cut off by thrust fault at 250 ft. below tunnel level. The Mulcahy vein was intersected by the crosscut tunnel at 410 ft. north of the portal, with drift northwest on the vein 500 ft. and southeast 240 ft. The high-grade streak on the footwall of the vein has a width of 30 in. The total width of vein is 30 ft. Reported total amount of underground workings on property is about 12,000 ft. The company is at present conducting mill tests to determine the type of mill to be installed to treat lead-carbonate, gold-silver ores developed on the property.

Equipment consists of 2 compressors, one of 360-cu. ft. capacity, driven by 75-h. p. motor, the other of 160-cu. ft. capacity. Tugger hoists are used underground for development below tunnel level. Electric power is secured from the Southern Sierras Power Co. Water is secured from a well on the property below the mine, depth of which is 250 ft. The water is pumped with Gould triplex pump through $2\frac{1}{2}$-in. pipe line to storage tank. Lift is 218 ft.

Twenty-five men are employed on development work.

Bibl.: State Mineralogist's Reports XI, p. 343; XVII, p. 351; XXVII, pp. 358-359.

Calico-Odessa Group of Mines. This group of mines consists of a number of former producing properties known as the *Baltic, Bismark, Garfield, Odessa* and *Thunderer* consolidated under one ownership, known as the Calico-Odessa Group. The holdings comprise 21 patented claims, totaling 300 acres, with 23 claims held by location, making a total of approximately 500 acres situated in Sec. 10, 11, 14, 15 and 23, T. 10 N., R. 1 E., in Calico Mining District, 5 miles northwest of Yermo, a station on the Union Pacific Railroad. Elevation 2600 ft. to 2800 ft.; owner, Mrs. J. R. Lane, Yermo, Calif.

The principal development work and the main production of ore has been on the Bismark, Garfield and Thunderer, and Odessa Group

of Mines. The principal orebodies developed occurred along a series of faults in a rhyolite tuff. On the Bismark-Occidental group of claims are two faults. The Bismark fault strikes N.-S., dips 30° W. Chlorides and chlorobromides of silver occur in irregular fractures and joint planes in a mineralized zone along this fault fissure. The ores are cerargyrite and embolite, with a little chrysocolla, in a gangue of barite. The Occidental fault strikes N. 15° E., dip 35° W. and the orebodies occur in a mineralized zone along this fault fissure.

The Garfield-Thunderer is situated on a ridge west of Odessa Canyon. The formation in which the mineralization occurs is a violet-brown liparite. The principal orebodies developed and mined occurred along the Garfield fault which strikes NW. and SE. and dips 75° SW. The silver ores occurred in a brecciated and fractured zone south of the fault in rhyolite tuff. The argentiferous minerals are cerargyrite and embolite occurring in a gangue of barite. The main production of silver ore came from this group of claims. Development consists of two tunnels. The lower Garfield tunnel is driven along the Garfield fault for a distance of 4000 ft. One hundred ft. in elevation above this tunnel is the upper tunnel driven along the fault for a distance of 2500 ft. Large chambers of ore were mined through these tunnels in a fractured zone; on both sides of the fault, the different stopes show lengths of 300 ft., with widths of 40 ft.

The Odessa Mine is situated on a ridge west of Odessa Canyon, at an elevation of 2700 ft. Chlorides and chlorobromides of silver are found in seams and fractures along the Odessa fault which strikes N. 40° W. and dips 70° SW. Development consists of the Odessa tunnel which is driven 600 ft. on the Odessa fault. Idle.

Bibl.: State Mineralogist's Reports VIII, p. 497; XI, p. 343; XII, pp. 608-609; XVII, pp. 362-363; XXVII, pp. 343-345.

Dietzmann Group of Mines. It comprises 2 patented claims, known as Bell Keg and Non Parallel and 4 unpatented claims adjoining the Baltic Group on the east, in the Calico Mining District, in Sec. 23, T. 10 N., R. 1 E., S. B. M., 5 miles northwest of Yermo; elevation 2600 ft.; owner, *Oro Grande Mining Co.*

Chlorides and chlorobromides of silver occur in brecciated zone in rhyolite tuff. Development consists of open cuts and short tunnels. Idle.

Imperial Lode Mine (Cave Springs Mining Corp.). It comprises 3 patented claims known as Mammoth Chief, Queen of the Desert and Meteor; also 3 claims held by location in Sec. 35, T. 7 N., R. 5 E., S. B. M., in the Lava Beds Mining District, 9 miles southwest of Lavic, a station on the Santa Fe Railroad; elevation about 4000 ft.; owner, *Cave Springs Mining Corp.*, W. W. Tucker, president; M. S. McLeon, secretary, 1131 Valencia St., Los Angeles.

The Imperial lode which can be followed along its outcrop for about 8000 ft., occurs in quartz-porphyry, strike N. 70° W. and dips 70° S.; width 6 ft. to 20 ft. A felsitic intrusive dike cuts across the lode at 3500 ft. from its west end. This dike follows the hanging wall of the vein for a considerable distance to the west. The lode is made up of quartz, barite, calcite and manganese. The ore occurs in shoots and bunches in the vein. The principal value of the ore is in its silver

content which occurs as chloride and sulphide (argentite), associated with pyrite, chalcopyrite and iron oxides; also occurs with lead carbonate ores. Some of the lead carbonate ore mined is said to carry as high as 200 oz. in silver. The chloride of silver is found associated with iron and manganese.

The principal development work is on the Meteor, Mammoth Chief and Desert Queen claims. The Meteor shaft has a depth of 100 ft., with drifts on 50-ft. and 100-ft. levels; ore is stoped to surface. For a distance of some 800 ft. along the lode are open cuts and shafts, with drifts. The ore mined from these workings is reported to have had an average value of 25 oz. in silver. The reported production from the Meteor and Mammoth Chief workings is over $40,000 in silver ore. On the Desert Queen Claim, there is a crosscut tunnel to the vein with drift east on vein for 800 ft. Total underground development is 6000 ft. Orebodies developed have a width of 5 ft. to 18 ft.; 30 ft. to 50 ft. in length.

From June, 1937, to May, 1938, the property was under lease to Sam Mosher and J. D. Williams, of the *Imperial Smelting & Refining Co.* During this period 2000 tons of ore was shipped to the Garfield smelter of the American Smelting & Refining Co., Salt Lake, Utah. The average grade of ore shipped was 16.69 oz. in silver per ton, with low values in lead and copper. Idle.

Bibl.: State Mineralogist's Reports XI, pp. 349-354; XII, p. 376; XIII, p. 607; XVII, pp. 362-363; XXVII, pp. 347-348.

Lead Mountain Mine. It comprises 640 acres of patented land, in Sec. 36, T. 10 N., R. 1 W., S. B. M., in the Grapevine Mining District, 5 miles northwest of Yermo; owner, L. F. Copeland, Los Angeles.

The country rock is tuff, andesite porphyry. The ore-bearing fissure strikes NW.-SE. and dips 40° NE. Width of mineralized zone is about 100 ft., the ore bodies occurring irregularly throughout this area along the strike of the fissure. The vein material is a coarsely crystallized barite, with quartz containing iron oxides, galena, lead carbonate, manganese oxide and silver chlorides.

Developments: The principal workings are on the south slope of Lead Mountain. They consist of a series of open cuts and tunnels along the strike of the mineralized zone for a distance of 500 ft. A crosscut tunnel driven northeast 75 ft. crosscuts the mineralized zone. From this crosscut tunnel, a shaft is sunk on the fissure on an inclination of 33° to a depth of 210 ft. On the north side of Lead Mountain, a crosscut tunnel 1300 ft. in length was driven by the *Waterloo Mining Co.* of Calico in 1881 to 1896. There is a 240 ft. vertical raise from this tunnel level connecting with stope at bottom of incline shaft from upper workings. Deposit was worked by *Pacific Minerals Co.* during 1931-1933 for its barite.

Bibl.: State Mineralogist's Reports XX, pp. 199-200; XXVII, pp. 349-350.

Mowry Mine (formerly known as Gladstone or Halberg), comprising 12 claims, is in the Lava Bed District, 9 miles northeast of Lavic, a station on the Santa Fe Railroad. Geographically, it is the western extension of the Imperial Lode District. Owner is Mowry Mines Co., D. G. MacGregor, Box 620, Hynes, Calif.

The geology and orebodies of this property have been described by Storms in our Report XI, pp. 358-359.

There is some 2200 ft. of development work on these claims. Four shafts, none of which are now accessible, are reported to have been put down as follows: No. 1, 85 ft. deep; No. 2, 250 ft. deep, with levels at the 50, 100, 150 and 250-ft. horizons; No. 3, 175 ft. deep; No. 4, 100 ft. deep. Two tunnels, 105 ft. and 310 ft. long, respectively, with a 10-ft. winze in the latter, are also reported. This work, presumably all on the same fissure, is scattered over some 3000 ft. of its length. The vein is up to 7 ft. in width, mineralized with copper oxides, cerussite and galena, carrying silver and free gold. Idle.

Bibl.: State Mineralogist's Reports XI, pp. 358-359; XXVII, pp. 353-354.

Silver Bell Mine, comprising 8 claims, is in the Lavic Mountains, 17 miles southeast of Newberry Springs and 29 miles east of Daggett; owner, *Rare Metals Corp.*, Mrs. Ona J. Bellamy, president, 310 South Fir Ave., Inglewood, Calif.

The mountain on which these claims are located consists of a series of basic volcanic flows, capped by some 200 ft. of rhyolite. These formations are traversed by a series of roughly parallel fault fractures. Where these fractures cross the contacts, amygdaloidal zones of varying thickness have been formed, the vesicles being filled largely with green and white calcite. No metallic minerals were observed.

Development consists of a crosscut tunnel driven south 1050 ft.; raise 54 ft. to surface at about 260 ft. from portal. At 400 ft. from the portal, a winze has been sunk 100 ft. At this depth, a small flow of water was encountered. There is also a drift south 80 ft., at 160 ft. from the portal.

Mine equipment consists of 50-h.p. diesel engine, direct connected to 30 K.W. generator. An electric hoist serves the shaft.

The following mill, for the extraction of certain rare metals, has been erected on the property: 9 by 14 jaw crusher, 2 small sets of rolls, rotary, oil-fired furnace and redwood leaching tanks.

Bibl.: State Mineralogist's Report XXVII, pp. 355-356.

Union Mine. The property comprises 6 claims, adjoining the Waterloo Mine on the north, in the Calico Mining District, in Sec. 16, T. 10 N., R. 1 E., S. B. M., 4 miles northwest of Yermo; elevation 2300 ft.; owner, Union Mining Co., Jack Moore, president and manager, Yermo, Calif.

The vein consists of a shear zone along the contact of rhyolite-breccia and the sedimentary lake bed series. The vein trends N. 50° W. and dips 50° SW.; width 6 ft. to 30 ft. The ore occurs as iron-stained brecciated wall rock, carrying values in gold, silver and lead carbonate.

Development consists of crosscut tunnel driven northeast 400 ft. to vein, with a winze sunk on vein to a depth of 100 ft.

Equipment consists of compressor, air drills and tugger hoist. Six men are employed on development.

Waterloo Mine. The property comprises 8 patented claims situated in the Calico Mining District, in Sec. 16, T. 10 N., R. 1 E., S.

B. M., on the west slope of the Calico Mountains, 4 miles northwest of Yermo; elevation 1900 ft. to 2200 ft.; owner, Waterloo Mining Co., J. T. Weakely, president; P. H. Krick, secretary, Anaheim, Calif.

The orebodies occur along the Waterloo fault zone which strikes N. 50° W. and dips 40° SW. The Waterloo vein occurs on contact of sedimentary rocks and tuff-breccia. The tuff-breccia is the footwall of the orebodies. The orebodies mined were large, irregular masses and bunches that extended along the fault zone for a distance of 1100 ft. The stopes ranged up to 200 ft. in length, with widths of 20 ft. to 80 ft. A large tonnage of ore was mined and treated in the Waterloo Mining Company's mill near Daggett from 1881 to 1896. The ore milled is reported to have carried from 11 oz. to 20 oz. in silver per ton, with a loss of 5 oz. in the tailings. The ore is chlorides and chlorobromides of silver in a gangue of barite and jasper. The silver minerals are cerargyrite, embolite and a little chrysocolla.

Development: The lower tunnel is driven N. 30° E., 2300 ft. and at 1750 ft. from the portal intersected the main shaft which was sunk on the vein to a depth of 350 ft., on an inclination of 50°. The tunnel is entirely in the sedimentary rocks with inclusions of tuff members of the upper lake bed series. At 290 ft. in elevation above lower tunnel, the upper tunnel is driven as a crosscut N. 50° E., 600 ft. to the Waterloo vein and connecting with shaft on the fourth level.

From the incline shaft 5 levels have been driven on the vein at intervals of approximately 50 ft. At the elevation of collar of the shaft, first level is driven southeast of shaft from big stope from second level. The following is the amount of drifting on the different levels: (see map)

1st level	550 ft.
2nd "	700 "
3rd "	550 "
4th "	1500 "
5th "	900 "
6th "	500 "

Seventh level or Main crosscut tunnel level 2300 ft., with 300 ft. of crosscuts on seventh level. On fourth level, there are 800 ft. of crosscuts. The total amount of underground development is approximately 10,000 ft. Incline shaft and main tunnel level are in good condition and most of the levels are accessible.

There is a limited tonnage of ore exposed from third level to first level, southeast of shaft; also ore exposed on sixth level, northwest of shaft for a distance of several hundred feet which has not been stoped. Idle.

Bibl.: State Mineralogist's Reports VIII, p. 498; XI, p. 343; XII, p. 376; XIII, p. 609; XXVII, pp. 359-360.

Zenda Gold Mining Co. (Oriental-Silver King Mines), W. F. Staunton, president; T. R. Drummond, secretary and manager, 1253 Pacific Mutual Bldg., Los Angeles; under lease to John Coke, Calico, Calif. This company owns the *Oriental and Silver King Group* of Mines, comprising 35 patented claims, situated in Sec. 15 and 22, T. 10 N., R. 1 E., S. B. M., in the Calico Mining District, 3½ miles northwest of Yermo, a station on the Union Pacific Railroad; elevation 2500 to 2600 ft.

There are two systems of veins on the property known as the Oriental and Silver King fissures which occur in rhyolite tuff, along what is known as the King system of fault fractures. The Oriental vein intersects the Silver King vein near the southwest corner of the Silver King Claim. The vein system strikes NW. and SE. and dips 70° SW. Towards the southern end of the vein system considerable faulting has followed the fracturing, while at the northern end of the system, the deposits occur as typical fissure veins with well developed walls. Along this system of fault fractures the crushing of the rock and faulting reached its maximum on the Red Cloud and Red Jacket claims. Here, the rhyolite tuff in places is completely disintegrated and brecciated; and barite and jasper are deposited in cracks and seams, running in all directions through the brecciated mass. The ores found along these fissures are similar in character. The gangue of barite and jaspery silica encloses more or less uniformly distributed chlorides and chlorobromides of silver. Cerargyrite and embolite mostly occur as thin coatings in joints and cracks but also often imbedded in the barite. The ore shoots are irregular and occur along the fault fissures, forming ore bodies 20 ft. to 50 ft. in thickness. The ore mined is reported to carry 10 oz. to 40 oz. in silver. In lower levels, some irregular lenses were encountered mineralized with chalcopyrite, tetrahedrite and pyrite.

Development: The Silver King and Oriental veins are developed by two shafts. No. 1 Shaft is a vertical shaft 340 ft. in depth and 542 ft. southeast of No. 2 Shaft which is a 3-compartment, vertical shaft, 550 ft. deep, with drifts and crosscuts on the 320, 430 and 530-ft. levels. The total amount of development from No. 2 Shaft consists of 15,000 ft. of crosscuts and drifts on the above-mentioned levels. On the 530-ft. level crosscuts have been driven northeast to the Silver King vein. A drift on the 320-ft. level connects with the workings from No. 1 Shaft.

Mine equipment: Steel headframe; double drum, electric hoist, driven by 75-h.p. motor; 500-cut ft. Ingersoll-Rand compressor, driven by 100-h.p. motor; Aldridge triplex pump, driven by 100-h.p. motor, capacity 500 gal. per minute; Pomona electric pump; blacksmith and machine shops.

Four men employed mining high grade ore for shipment.

Bibl.: State Mineralogist's Reports VIII, pp. 491-498; IX, p. 224; X, p. 530; XI, pp. 337-344; XII, p. 376; XIII, pp. 606-607; XVII, pp. 359-366; XXVII, pp. 362-364; Trans. Am. Inst. of Mining & Metallurgical Engrs. Vol. XV, p. 718.

NONMETALLIC MINERALS

The most important development in recent years has been the discovery and development of bentonite deposits in the vicinity of Hector, San Bernardino County. The increased demand for collodial clay of the bentonite type in place of true fuller's earth because of its being utilized for clarifying, filtering and cleansing purposes and the use with barite as oil-well drilling material to seal off the formation in drilling of deep oil wells, has led to the development of a number of important deposits in the Newberry Mountains. The more important

of the nonmetallic minerals thus far exploited as shown by output are: Barite, bentonite, celestite, and fluorspar.

Barite

A considerable tonnage of barite has been mined in the past in the vicinity of Barstow and Ludlow but with the exception of the deposits on Lead Mountain, most of the deposits mentioned have been worked out. The gravity of the barite mined varied from 3.9 to 4.2. The largest tonnage mined was used with bentonite in the oil fields of California.

Barium Queen Mine, consisting of 3 claims, is 5 miles northeast of Barstow, in T. 10 N., R. 1 W., S. B. M. It is on the south slope of a low range of hills north of Mojave River; elevation 3000 ft.; owner, Ellis Mallery, 214 H. W. Hellman Bldg., Los Angeles.

A series of parallel veins occurs in quartzite and schist; strike N. 30° W., dip 70° NE. The main vein developed and worked can be traced for 4500 ft. and is from 4 ft. to 5 ft. wide. Development consists of a tunnel 250 ft. in length, with a number of shafts from 25 ft. to 60 ft. in depth. A considerable tonnage was shipped. Used for conditioning oil well mud. Idle.

Bibl.: State Mineralogist's Reports XVII, p. 334; XXVII, p. 371.

Big Medicine Barite Deposit. It is 6 miles northeast of Barstow and 1½ miles south of Lead Mountain; owners, George Parks and Dr. Smith, Barstow, Calif.

On the northeast slope of a range of hills, a vein has been exposed by a small open cut; strike N. 45° W., dip 30° NE. It shows here a width of 4 ft. to 6 ft. and is filled with iron-stained barite. About 1500 ft. northeast of this open cut, a vein of barite 8 ft. wide has been exposed by an open cut. The open cut is 50 ft. long and 20 ft. deep. Some high grade ore was shipped from the deposit. Idle.

Bibl.: State Mineralogist's Report XXVII, p. 371.

Hansen Barite Deposit. It comprises 4 claims, situated 3½ miles north of Ludlow, in Sec. 19, T. 8 N., R. 8 E., S. B. M.; owner, Harry B. Hansen, Ludlow, Calif.

The vein of barite is from 3 ft. to 14 ft. in width; strike N. 45° W., dip 45° NE.; in a basaltic formation. The ore shoot worked was 150 ft. in length; average width 6 ft. and mined to a depth of 60 ft. Approximately 4000 tons of barite has been mined and shipped from the deposit.

Bibl.: State Mineralogist's Reports XXVI, pp. 54-55; XXVII, pp. 371-372.

Lead Mountain Barite Deposit. It is situated in the Grapevine Mining District, in Sec. 36, T. 10 N., R. 1 W., S. B. M., 6 miles north of Barstow. Holdings comprise 640 acres; owner, L. F. Copeland, Los Angeles.

The country rock is tuff, limestone and andesite. The ore-bearing fissure strikes NW. and SE. and dips 40° NE. The width of the ore zone is about 100 ft. and is exposed for a distance of 1300 ft. The

vein material is coarsely crystallized barite, with quartz containing brown iron oxides, galena and lead carbonate, manganese oxides and silver chlorides.

The barite was mined in 1930 to 1933 by *Pacific Minerals Co.* and hauled to the company's mill at Barstow where it was concentrated to bring the gravity of the material up to 4.2. This company mined several thousand tons. In 1937 a number of cars of ore were mined from surface cuts and shipped to the *California Talc Co.*

Development consists of crosscut tunnel driven north 150 ft. crosscutting the barite lode, with drifts northwest and southeast on the vein. Idle.

Bibl.: State Mineralogist's Reports XX, pp. 199-200; XXVII, p. 372.

Mansfield Barite Deposit. It is situated 6 miles north of Barstow. Idle.

Bibl.: State Mineralogist's Reports XV, p. 853; XVII, p. 334; XXVII, p. 372.

Pluth Barite Deposit. It is situated 4 miles north of Daggett; owner, Marcus Pluth Estate, Daggett, Calif.

Bibl.: State Mineralogist's Reports XVII, p. 334; XXVII, p. 373.

Waterman Mine Tailings is 4 miles north of Barstow, Calif.; owner, Mrs. W. M. Waterman, Barstow, Calif.

Bibl.: State Mineralogist's Reports XXVI, p. 55; XXVII, p. 373.

BENTONITE[1]

Origin and Classification

Bentonite is a name first applied to a clay-like, soapy substance found in the Benton formation near Rock Springs, Wyoming. This substance was highly colloidal, and, dispersed in water, it formed a thixotropic gel. Chemically, alumina and silica were the predominating materials in its composition. Bentonite was thus defined as an anhydrous alumina silicate and thereafter other clay-like substances containing a predominance of alumina and silica were classified as bentonites, though many differed materially as to their physical characteristics from the first named bentonite. Davis and Vacher[2] attempted to reconcile these differences, suggesting a further classification into alkali type bentonites and sub-bentonites, believing the differing physical properties were due to the presence or lack of an exchangeable alkali base.

A few years later a substance found near Hector, California, exhibited identical physical characteristics to those of the Wyoming bentonite. Upon analysis, magnesium and silica were determined as predominating in its composition. This substance did not, of course, correspond to the definition for bentonite which had been defined as an anhydrous alumina silicate.

[1] By R. E. Scott, Jr., National Pigments & Chemical Division, National Lead Co.
[2] Technical Paper 438, U. S. Bureau of Mines.

Forshag and Woodford [3] have attempted to identify this material as saponite. This would assume its origin to be similar to that attributed to all clays, namely, a product of alteration or decomposition of some igneous rock in place.

The more generally accepted theory of the origin of bentonite is that it was a finely divided volcanic ash or lava dust, expelled from a volcano and subject at sometime to highly corrosive gases as well as a moist atmosphere or laid down in a body of shallow water.

The evidences observed with respect to the colloidal bentonites, as well as the so-called saponite, seem to support this theory. Fossilized bones and plant life have been found beneath the orebodies. Geodes and chalcedony specimens which occur dispersed throughout the orebodies seem of sufficient evidence that the ore was at one time laid down much in its present form. Deposits examined in different localities, each differ with respect to the contact rock in place. In one locality granite predominates, in another sandstone and still in another limestone dykes form the contact side and footwalls.

It is probable that the so-called filter-clay type bentonites may have originated from decomposed rock in place. If they are of volcanic origin and were laid down similarly to the colloidal type bentonite, they have most certainly been considerably altered since and differ physically from the Wyoming substance, after which they were named.

Some authorities classify all clay-like substances that show a predominance of alumina and silica as bentonite. It is more logical to define bentonite as a colloidal clay-like substance which when dispersed in water forms a thixotropic gel. It is suggested that they be classified as colloidal alumina-silicate-type bentonites and colloidal magnesium-silicate-type bentonites. The so-called filter clay substances which are defined non-colloidal should not come under the classification of bentonite, a name first given to the colloidal substance found near Rock Springs, Wyoming.

The filter clay substances are of commercial value because they contain little or no colloidal matter. As they contain a large percentage of solids they provide an efficient filtering medium for the filtering of mineral and vegetable oils. The colloidal bentonites and the so-called saponite prevent filtration. A film as little as 1/16 of an inch thick will not permit filtration of water under high pressures.

The so-called filter-clay types, when dispersed in water, do not form thixotropic gels; at best they remain temporarily in partial suspension and settle upon standing. These non-colloidal substances which differ physically to such a degree from the material first called bentonite, should be under a separate classification.

Should further study indicate that they owe their origin to altered rock in place, they belong with the clay family. Their properties are similar in many respects to fuller's earth. Until recent years statistics of the tonnages of all type bentonites were classified under the heading of fuller's earth.

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[3] Journal Mineralogical Society of America; also Bull. 113, Calif. State Division of Mines.

Geology and Mining

Mining the colloidal type bentonites which are found in Wyoming, South Dakota and sections of Canada, is comparatively simple. The ore occurs in large, shallow beds close to the surface. Overburden is usually removed with a scraper, after which the exposed surface is carefully swept. The ore is produced to a depth of from 2 ft. to 3 ft. after which it is dried artificially since it contains from 20% to 30% moisture.

Mining at Hector, Calif. is not quite so simple. Here the ore occurs in pockets varying in size from a few tons to many thousand tons. The pockets are frequently some depth below the surface. Ore taken from the northern section of these properties closely resembles the Wyoming bentonite and predominates in magnesium and alumina. The deposits in the northern section are covered with an overburden composed largely of loose, unconsolidated sandstone. Limestone geodes, with small manganese centers, occur at frequent intervals dispersed through the orebodies.

The occurrences in the south properties are similar to those in the northern sections, except that a lava capping from the Pisgah Lava Flow usually covers the standstone overburden and in place of limestone geodes, queerly-shaped specimens of chalcedony are dispersed throughout the ore. The contact materials here are also more often limestone dykes and footwalls. Quite frequently a thin, brown, tuff-like material is found between the overburden and the ore in both deposits. This appears to be a contaminated bentonite infused with flaky, quartz-like particles.

The deposits occur alongside of a dry lake bed which caused engineers to believe that the parent body, similar in extent to the Wyoming occurrences, would be located in the lake bottom. Though drilled extensively to depths of 50 ft. and 60 ft., ore has not been found to occur as they predicted.

The usual method of contacting the ore is to run an incline shaft from the surface, following limestone footwall. Heavy timbering is required to hold the loose overburden which will vary from several feet to 50 ft. or 60 ft. in thickness. A face of ore may open up as a small stringer, or may present a face 30 ft. to 40 ft. in height and a similar distance in width. The incline of the footwall may vary, pitching principally southwest. The exposed ore tends to slack when exposed which causes the roof to take weight frequently crushing large-sized timbers. For this reason, only small areas are opened at a time and then permitted to cave when depleted.

At Hector, Calif., sunshine is utilized to dry the ore. Besides being less costly than artificial drying, it is superior as great care must be taken not to expose the ore to extreme temperatures as heat destroys the colloidal properties. Because of its peculiar nature bentonite requires long, slow-drying as the dried surface tends to seal in the remaining earth moisture. When exposed to sun and warm air it slacks readily and permits further exposure to the still damp surfaces thereby exposed.

BENTONITE DEPOSITS

Deposits of bentonite of commercial importance occur near Hector, in T. 9 N., R. 5 E., and T. 8 N., R. 5 E., S. B. M., the principal producer in this area being the California Talc Co., a subsidiary of the National Pigments & Chemical Division of the National Lead Co. The deposits have been under production since 1931.

California Talc Company's Bentonite Deposit. The property comprises fourteen 160-acre placer claims, approximately 2200 acres, situated in Sec. 31, T. 9 N., R. 5 E. and in Sec. 22, 23, 24, 26 and 27, T. 8 N., R. 5 E., S. B. M., the Lemon or south deposits being located 3 miles south of Hector and the north deposits are located 3½ miles west of Hector, a station on the Santa Fe Railroad; elevation 2000 ft.; owners, *National Pigments & Chemical Division of National Lead Co.;* offices, 830 Ducommon St., Los Angeles; Geo. L. Radcliffe, president; R. E. Scott, secretary and manager; Percy Stamdinger, superintendent.

South Deposit: Bedded deposit of bentonite that is covered by flow of basalt. The beds strike NW. and SE. Dips vary from 12° to 20° to SW. The thickness of the bentonite beds vary from 6 ft. to 40 ft. The basalt overlying the bentonite beds is from 12 ft. to 15 ft. thick. The bentonite mined is white to gray in color, with high magnesium content. Since our last report (Vol. XXXVI, pp. 81-82), a new incline shaft has been sunk to a depth of 300 ft. about 500 ft. south of open cut and old shaft. This shaft is sunk on the limestone footwall on an inclination of 12°; on 300-ft. level, drift north-west connecting with workings from old shaft. The bed of bentonite is from 8 ft. to 10 ft. in thickness, with 5 ft. of white bentonite on footwall and 4 ft. to 5 ft. of brown bentonite on hanging wall clay, overlain by basalt. The old shaft workings produced 25,000 tons of commercial bentonite. The bentonite mined is hoisted by 15-h.p. gas engine hoist to bunkers. From bunkers, the material is loaded into trucks and hauled to drying platform at Hector Siding. The material is sun dried, then loaded into railroad cars for shipment to the company's grinding plant in Los Angeles. At present, no work is being done on the north deposit. The material mined from the north deposit is a calcium magnesium, aluminum silicate, of lower magnesium content than the south deposit. Ten men are employed.

Bibl.: State Mineralogist's Reports XXVII, pp. 380-381; XXXVI, pp. 81-82.

Ewrite Bentonite Mine. It comprises 160-acre placer claim, situated in Sec. 35, T. 8 N., R. 5 E., S. B. M., adjoining the California Talc Company's property, on the south and west; owner, Oscar H. Horner, Newberry, Calif.; under lease to *Pizgah Minerals, Inc.;* N. W. Clark, president, 625 A. G. Bartlett Bldg., Los Angeles.

Bed of bentonite strikes N. and S.; dip 5° to 10° W.; thickness 6 ft. to 8 ft. Developed by 2-compartment, vertical shaft 72 ft. deep; drifts on 70-ft. level. Reported to have shipped 500 tons of bentonite from the property.

Equipment consists of 25-h.p. hoist and air compressor; 30-ft. headframe; skip with a capacity of 2 tons. Idle.

CLAY

Western Talc & Magnesite Company's Clay Deposit. It comprises 16 claims situated in Sec. 11 and 12, T. 9 N., R. 1 W., S. B. M., 5 miles east of Barstow; owner, Western Talc & Magnesite Co., Los Angeles.

Beds of fire clay occur on the claims suitable for the manufacture of fire brick. Development consists of shafts and open cuts. Idle.

Bibl.: State Mineralogist's Report XXVII, p. 375.

STRONTIUM

The DuPont Co. owns a large deposit of celestite ($SrSO_4$) in Sec. 19 and 30, T. 8 N., R. 7 E., in the Cady Mountains, about 4 miles northwest of Argus Siding, on the Santa Fe Railroad and some 6 miles northwest of Ludlow.

The deposit is estimated to be 150 ft. wide and is traceable for some 2000 ft. A considerable tonnage of this material was shipped during the first world war. Idle.

Bibl.: State Mineralogist's Reports XV, pp. 898-899; XVII, pp. 366-367; XXVI, p. 323; U. S. G. S. Bull. 540, pp. 526-531; 660-1.

Rowe & Buehler Deposit is in the SE. ¼ of Sec. 19 and NW. ¼ of Sec. 30, T. 8 N., R. 7 E., S. B. B. & M., about 6 miles northwest of Barstow; owners, Wesley N. Rowe, 919 East Valley Blvd., Rosemead, Calif., and Wm. C. Buehler, 1555 Sunset Ave., Pasadena, Calif.

Analyses of this deposit indicate from 76.3% to 84.6% $SrSO_4$. A report on this deposit was written for the U. S. G. S., by Bernard N. Moore, in "Strontium Deposits of Southeastern California & Arizona"; also Technical Publication No. 599, in 1935, A. I. M. E. Journal.

GEOLOGIC BRANCH

CURRENT NOTES

By Olaf P. Jenkins, Chief Geologist

New Treatise on Oil and Gas Resources of California

Widespread need for an up-to-date treatise on the history, production, economics, engineering technique, and geology of the oil and gas resources of California has prompted the Geologic Branch to prepare Bulletin 118, GEOLOGIC FORMATIONS AND ECONOMIC DEVELOPMENT OF THE OIL AND GAS FIELDS OF CALIFORNIA.

Part One, DEVELOPMENT OF THE INDUSTRY, is now completed; while Part Two, GEOLOGY OF CALIFORNIA AND THE OCCURRENCE OF OIL AND GAS, is now in press. The remaining Part Three, DESCRIPTIONS OF THE INDIVIDUAL OIL AND GAS FIELDS, and Part Four, GLOSSARIES, BIBLIOGRAPHY, AND INDEX, are well under way, so far as manuscript copy is concerned.

A limited supply of preprints of Part One of Bulletin 118 is being made available prior to the final distribution of the entire bound volume, through subscription to all four parts. The contents of Part One are as follows:

Chapter III——Early History

Aboriginal Use of Bitumen by the California Indians, by Robert F. Heizer

History of Exploration and Development of Gas and Oil in Northern California, by Walter Stalder

Since the guiding science of the industry has been geology, this subject has been made the principal theme of Bulletin 118. Though the many separate reports that make up the book are necessarily very brief, a sincere attempt has been made to give the salient data in condensed form, and to present the published sources in a manner which will enable the reader readily to find them.

The new Geologic Map of California has been in need of a companion—descriptive, interpretative, historical, stratigraphic—and a treatise such as this should help to present the complex sedimentary record of the State, especially as it is related to the oil and gas industry.

Earlier statewide reports by Watts,[1] Prutzman,[2] McLaughlin and Waring,[3] and Vander Leck,[4] have long been out of print. These earlier bulletins described the industry as it was over a quarter of a century ago. They were issued by the old State Mining Bureau a number of years before the creation of the Department of Natural Resources (1927), which resulted in the separation of the Oil and Gas Division from the Division of Mines. Since the Oil and Gas Division assumes regulatory duties only, and since the Division of Mines has concerned itself for the most part with other mineral resources, there seemed to be no place where a new statewide bulletin on the oil and gas resources might be prepared. In 1929, however, the Division of Mines established the present Geologic Branch; and now, following the publication of the Geologic Map of California in 1938, this branch has undertaken the job of assembling the material for this bulletin, "Geologic Formations and Economic Development of the Oil and Gas Fields of California."

The success of the Geologic Branch in securing support from all available authoritative agencies in the making of the state geologic map, suggested the idea of employing the same method in the preparation of this book. In fact, with the present limited regular staff of three, whose duties are many and varied, the present work could hardly have been done in any other manner. But with the whole-hearted support given by a large number of authorities (more than 100) in the profession, the result has been very gratifying, indeed. Each chapter is handled in a manner that will undoubtedly make this bulletin the outstanding authority on the subject for many years to come.

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[1] Watts, William L.
The gas and petroleum yielding formations of the central valley of California. California State Mining Bureau, Bulletin 3, 100 pp (1894).
Oil and gas yielding formations of Los Angeles, Ventura, and Santa Barbara Counties. California State Mining Bureau, Bulletin 11, 94 pp (1897).
Oil and gas yielding formations of California. California State Mining Bureau, Bulletin 19:236 pp, Sacramento (1901).

[2] Prutzman, Paul W.
Production and use of petroleum in California. California State Mining Bureau, Bulletin 32, 230 pp (1904).
Petroleum in southern California. California State Mining Bureau, Bulletin 63, 430 pp (1913).

[3] McLaughlin, R. P., and Waring, C. A.
Petroleum industry of California. California State Mining Bureau, Bulletin 69, 519 pp, map folio (1914).

[4] Vander Leck, Lawrence.
Petroleum resources of California with special reference to unproved areas. California State Mining Bureau, Bulletin 89, 186 pp (1921).

GEOLOGY OF THE NEWBERRY AND ORD MOUNTAINS, SAN BERNARDINO COUNTY, CALIFORNIA*

By Dion L. Gardner **

OUTLINE OF REPORT

* Abridged from a Master's thesis presented to the Department of Geological Sciences, University of California, Berkeley, California.

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ABSTRACT

The oldest rocks of the area (Archean ?) consist of a metamorphosed sedimentary series (marble, gneiss, and quartzite) which has been intruded by a group of meta-plutonic rocks (diorite gneiss, diorite, and granite porphyry). Following the formation of this crystalline complex, a long period of erosion is indicated by the deposition of Cambrian (?) quartzite upon an even surface cut in the Archean rocks. Upper Paleozoic (?) quartzite, with marbles and quartzites of unknown age, is also found within the area. These Paleozoic sediments occur as discontinuous patches included within Jurassic (?) plutonics. A maximum thickness of 360 feet was observed.

Mesozoic rocks are represented by the Ord Mountain group of Triassic (?) age, and by Jurassic plutonics. The Ord Mountain group is divisible into two units, each of which is further subdivided. The oldest unit consists of andesitic lavas, tuffs, and breccias, which are intruded by the rocks of the second unit—meta-porphyry, andesite porphyry, and monzonite porphyry. The plutonics, correlated with the Nevadan intrusives, range from granodiorite to granite; quartz monzonite is most common. These granitic rocks are divisible into four units with definite time relations between them.

Following the intrusion of the plutonics, the cover and upper portions of the granite were removed over wide areas. No depositional record is shown within the area until mid-Tertiary time. A peneplain with exterior drainage, possibly to the west, may have been developed.

The earliest Tertiary record shows a series of sediments, lava flows, and agglomerates deposited unconformably upon the basement complex. Then came a period of andesitic eruptions, followed by erosion and the deposition of thick fanglomerates containing abundant fragments of andesite. Volcanic activity was renewed with the extrusion of the Black Mountain basalt. As a late event in this period of vulcanism, lavas were erupted from Mt. Pisgah and Sunshine Peak cones. Rhyolite material of limited areal extent is interbedded in the Black Mountain basalt. In many localities a series of gravels occur which have been derived from the Black Mountain basalt and consist largely of basalt fragments. Faulting and differential uplift are interspersed in the

above sequence, and have outlined the position of the low- and high-standing areas.

The fault systems are divisible into (1) northward-trending rifts, (2) east-west faults, and (3) northwest-trending faults. The structure is considered to be due to differential movements of blocks within the Lucerne-Dale trough and the Barstow-Bristol trough, which are the major structural features of this portion of the Mojave Desert.

Mineral deposits within the region are divided into (1) iron ore deposits, (2) gold and copper deposits, and (3) gold lode and placer deposits.

INTRODUCTION

Location and Extent of Area. The area described in this report lies in the Mojave Desert, San Bernardino County, southeast of Barstow, California, between 116° 00′ and 117° 00′ west longitude, and 34° 30′ and 35° 00′ north latitude.

The Newberry and Ord Mountains received the most detailed attention, while in the Southern Ord Mountains, Fry Mountains, Lava Bed Mountains, Sunshine Peak region, and Bristol Mountains, only a reconnaissance was made. Neither the Cady nor the Calico Mountains, which lie within the limits of the area, were examined.

FIG. 1. Index map. Ruled portion indicates area covered by accompanying map, Plate II. Cross-hatched portion shows areas geologically mapped by Dion Gardner. Black portion refers to area mapped and described in report on the Calico Mountains by H. D. Erwin and Dion Gardner.

Acknowledgments. Field work was done during the summers of 1930 and 1931 by arrangement with the Geologic Branch of the California State Division of Mines. For the opportunity of initiating the work, the writer is indebted to Walter W. Bradley, State Mineralogist, and to Olaf P. Jenkins, Chief Geologist, of the California State Division of Mines.

Criticism and assistance was given by C. D. Hulin, Professor of Geology, University of California, Berkeley. Messrs. J. C. Hazzard,

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Topographic base maps (scale, 1 inch equals 10,000 feet; contour interval, 100 feet) were supplied through the courtesy of the Metropolitan Water District of Los Angeles, California.

GEOGRAPHY

Accessibility. U. S. Highway 96 and the main line of the Atchison, Topeka, and Santa Fe Railroad traverse the area in an east-west direction between Ludlow and Daggett. The area is also accessible from Lucerne Valley and Victorville, which lie to the south and west. Good roads are scarce within the mountains, but those indicated on the accompanying map were passable in 1936.

Climate and Vegetation. The climate is arid and similar to that which prevails in adjacent portions of the Mojave Desert. Summers are dry and hot, with winds frequently accompanied by sand and dust. Daytime temperatures range from 100° to 115° F., becoming less at higher elevations.

Summer rainfall is scanty and concentrated in local thunder showers which may become torrential. During winter months, prevailing low temperatures are accompanied by sporadic rain and snow.

Vegetation is of the arid type, and is most abundant at high elevations because of the greater precipitation. Discussions of the flora of the Mojave Desert are given by Thompson [1] and Meinzer.[2]

Topography. The general topographic features of the Newberry and Ord Mountain region are similar to those elsewhere in the Mojave Desert. Block-faulting and subsequent erosion have resulted in the formation of regular and irregular mountainous areas surrounded by detrital material. The highest point in the area is the summit of Ord Mountain, 6,300 feet above sea level. The surrounding country ranges from 2,000 feet to 6,000 feet in elevation; east of Ludlow elevations are lower.

The names and locations of drainage basins and mountain areas given on the accompanying map were obtained from several sources, the most important of which was Thompson's report.[3] As far as possible, terms previously adopted have been used; in some instances it was necessary to supply suitable geographic names.

The drainage basins of the region are closed, bounded by fault-block mountains. Playas, or dry lakes, often broad and extensive, occupy the lowest portions of the basins. Surrounding the playas and rising to the hills are alluvial fans and cones. Escarpments rise near the heads of the fans.

The drainage system is divisible into several units. To the north, the streams flow into the Barstow-Bristol trough; to the south and southeast, they rise in the summit areas of the Newberry and Ord Mountains, and flow into the Lucerne-Dale trough; west of Ord Mountain, they flow into Stoddard Valley; north of Ludlow, they flow into Broadwell Basin.

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[1] Thompson, D. G., The Mojave Desert region, California. USGS, W-S P 578, 1930.

[2] Meinzer, O. E., Plants as indicators of ground water. USGS, W-S P 577, 1927.

[3] Thompson, D. G., *op. cit.*

ECONOMIC GEOLOGY

Water Resources[4]

Locations of springs and wells furnishing water are shown on the accompanying map. So far as is known, water, at least in small quantities, is always available at these places. In the Ord Mountains, the most dependable sources are Aztec, Cottonwood, and Taylor Springs, and Willis Well. In the Newberry Mountains, dependable water is found at Kane and Newberry Springs. In the Sunshine Peak region, reported arsenic causes all water to be viewed with suspicion.

Mineral Deposits

Iron Ore. Near the southern end of Iron Ridge, and in scattered localities in Bessemer Basin, irregular, discontinuous masses of magnetite occur. They are found in or near marble xenoliths included in plutonic country rock.

Gold and Copper. Copper and gold ores occur as discontinuous vein deposits in the Ord lavas and tuffs, and in the meta-porphyry of the Ord Mountain group on Ord and Kane Mountains. The only persistent vein system is on the southwest side of Ord Mountain in a fault zone which strikes northwest and dips north. The ore deposits are irregularly distributed along a branching vein system approximately five miles in length, and from 100 ft. to 200 ft. in width. This system is bounded on the north by the Ord lavas and tuffs, and on the south by meta-porphyry and quartz monzonite. Primary ore minerals are chalcopyrite, bornite, and gold; gangue minerals are quartz, scheelite, and calcite. Alteration of the sulphides near the surface has resulted in the formation of malachite and azurite.

The deposits may be mesothermal, for the minerals are medium- to fine-grained, and druses are not common; in one locality, however, the glassy nature of the quartz in the veins carrying gold and copper implies an epithermal origin. Furthermore, the veins are deposited in faults which offset rhyolite dikes that may have been injected near the surface. The erratic distribution of minerals, the brecciation, and the location of minerals along fracture lines indicate that the deposits were formed by accretion.

Gold (Lode and Placer). Gold ores occur in narrow veins and as impregnations in fractures along sheared and smashed zones in the quartz monzonite, quartz porphyry, monzonite porphyry, andesite breccia, and acid dikes. The Grand View, Ord Belt, and Gold Belt mines in the Ord Mountain district belong to this group, and the Sunshine Peak and Pacific mines south of Ludlow are probably of the same type.

In most cases the veins are not persistent; they are variable in width, continuity, and gold content. Gangue is fine-grained drusy quartz, which is in some places iron-stained. Gold occurs most frequently as impregnations in the country rock. Small quantities of sulphides (pyrite and arsenopyrite) are the only ore minerals associated with the gold. The ore is primary; though oxidized, it has undergone little secondary enrichment. At the Grand View mine, the deposit

[4] Thompson, D. G., *op cit.*

has been enriched by mechanical concentration of the gold in cracks and crevices.

Deposition of gold quartz veins was presumably from ascending heated solutions. The textural features indicate that such deposition was in the epithermal zone under low temperature and pressure conditions. The period of mineralization was at least as late as Miocene, for the deposits cut acid and basic dikes of Miocene age.

The older alluvium and higher gravels of Lewis Camp and Stoddard Valley are auriferous. Gold is also found in Recent alluvium at Camp Rock.

DESCRIPTION OF THE GEOLOGIC FORMATIONS[5]

Archean

There are two distinct rock groups of probable Archean age within the region: (1) meta-sediments, and (2) plutonics.

Meta-Sediments

Archean rocks referable to the meta-sedimentary assemblage occur in the Newberry Mountains in two localities.

Kane Canyon. About $1\frac{1}{2}$ miles east of Kane Springs, on the west side of Kane Canyon, nearly 1,000 feet of interbedded gneiss, marble,

FIG. 2. Banded Archean (?) gneiss in Kane Springs Canyon, Newberry Mountains.

and quartzite occur, with an areal outcrop of less than one-half a square mile. The depositional base is not exposed, so the original thickness is not determinable. The meta-sediments are intruded on the northeast by quartz monzonite, and on the west by a fine-grained Tertiary rock. Banding of the gneiss and quartzite parallels the stratification of the marble, striking north and south, and dipping 60°-70° E.

The major part of the section consists of biotite-orthoclase gneiss, which grades into an altered quartzite near the eastern tip of the ridge.

[5] Determination of the rock types as listed in the succeeding pages represents the results of petrographic examination by the author in the geological laboratories of the University of California.

Marble crops out at the eastern limit of the ridge. In a zone immediately below the marble, both orthoclase quartzite and biotite quartzite are found, changing westward into normal gneiss.

Petrology: The biotite-orthoclase gneiss is medium-grained, with distinct gneissic banding. Pink bands of equi-dimensional quartz (20%), orthoclase (48%), and oligoclase (5%), alternate with bands of dark biotite (20%). Magnetite, titanite, and zircon are present as minor constituents. Zircon grains commonly show rounding of the edges.

The orthoclase quartzite has a blasto-clastic texture. It consists of alternating bands of flesh-colored orthoclase and quartz, with thin, dark, biotite bands. Biotite quartzite shows a well-defined blasto-clastic texture, but is distinctly gneissic. It is composed of orthoclase (20%), quartz (70%), and brown biotite. Magnetite, titanite, and zircon are present in both.

The marble is similar in character throughout, consisting of grains of medium to coarse calcite. Magnetite, diopside, and garnet are present in small amounts.

Origin: Two alternative theories as to the origin of the group may be advanced: (1) metamorphism of an interbedded feldspathic series with simple recrystallization and little or no addition of material; (2) derivation from a similar series by the replacement of the original constituents by feldspar.

The original sedimentary character of the group is indicated by: (1) the gradational change from gneiss to mixed gneiss and quartzite, then to marble with interbedded quartzite; (2) the presence of rounded zircon grains within the gneiss. The sieve textures and replacement borders indicate that the quartz has been displaced by orthoclase either by recrystallization or by replacement from emanations. While it does not seem possible to distinguish definitely between these modes of origin, the unit as a whole originated under extreme pressures and temperatures.

Iron Ridge. Near the southwestern tip of Iron Ridge are xenoliths of coarse white marble included in Archean diorite. In Bessemer Basin other marble xenoliths occur southwest of the playa. The marble consists of recrystallized grains of calcite with sparse magnetite grains. Small amounts of epidote and diopside occur.

Plutonics

The second Archean group is widespread. Outcrops occur in Bessemer Basin, along Iron Ridge, in the Newberry Mountains, in the Southern Ord Mountains, and in numerous other localities. While these rocks are variable in appearance and in degree of metamorphism, there is a general separation of the plutonics into three groups. These are: (1) plutonics of Iron Ridge; (2) diorite; and (3) granite porphyry.

Iron Ridge. Iron Ridge bounds Bessemer Basin on the northwest, and is almost entirely composed of granitic rocks. Near the southwestern tip of the ridge, xenoliths of Archean marble occur. Tertiary volcanics are found to the northeast. The complex of Iron Ridge is intruded on the northwest by Cactus granite.[6] Medium-grained diorite and diorite gneiss comprise the bulk of the granitics in this area, although hornblendite is of common occurrence. Cactus granite dikes and tongues penetrate the earlier rocks.

Petrology: Megascopic examination of the rock shows the diorite to be medium-grained hypidiomorphic-granular. Essential constituents are plagioclase and quartz, with minor amounts of orthoclase. Hornblende is characteristic. The diorite gneiss shows a slight re-orientation of minerals, but the effect is not pronounced.

Diorite. Fine-grained diorite occurs in the Newberry, Southern Ord, Fry, and Bristol Mountains. It is seldom exposed in large bodies,

[6] Vaughan, F. E., Geology of the San Bernardino Mountains north of San Gorgonio Pass. Cal Univ, Dp G, B 13: 365 (1922)

but occurs as small masses included in the surrounding plutonic. While diorite may crop out over areas several hundred yards in diameter, the exposed area is commonly less than 100 feet, ranging downward in size to a few feet or inches. Schlieren, present in the Jurassic hornblende-quartz monzonite, may represent partially resorbed inclusions of this earlier diorite.

Petrology: The texture of the diorite is fine-grained hypidiomorphic-granular. Essential constituents are oligoclase-andesine (60%) and orthoclase (5%); augite (13%), hornblende and uralite (12%), and biotite (9%) are characteristic minerals. Small quantities of magnetite, zircon, and apatite are present. The augite is generally surrounded by a definite rim of uralite.

In the gneissic variants, porphyroblastic plagioclase grains are surrounded by lenticular streaks of ferromagnesian minerals, probably the result of re-orientation of the minerals under regional stress, for the condition is widespread. Megascopic examination disclosed no essential difference between this rock and the diorite which has not been subjected to stress.

Granite Porphyry. Southeast of Little Wonder Ridge, a small, irregular area of granite porphyry is intruded on the northwest by Cactus granite, and on the east by the Sunshine Peak monzonite porphyry.

Petrology: The rock consists of partially altered porphyritic orthoclase and sparse quartz and augite crystals in a dark-colored, medium-granular groundmass consisting of subhedral and anhedral grains of augite, hornblende, and magnetite. The minerals of the groundmass crystallized simultaneously, although augite is often subhedral. In some instances the groundmass has entered fracture planes in the orthoclase, perhaps assisted by replacement.

Correlation of the Pre-Cambrian

Reference of the preceding rock types to the Archean is based upon fragmentary evidence, the most positive of which is the presence of quartzite (supposedly of Cambrian age) resting with erosional unconformity upon the diorite in Bessemer Basin. In the surrounding regions, no rock types such as those just described are known except in the pre-Cambrian. All Algonkian formations so far recognized in California and Arizona are of sedimentary origin, with the exception of volcanics. Therefore, as most of these rocks are of plutonic origin, it is assumed that the Algonkian is absent, and that the rock groups are of Archean age.

Correlation of the marble and gneiss of Kane Canyon with the Johannesburg gneiss is based upon the lithologic similarity of the two. The Johannesburg gneiss is considered to be Archean.[7]

Paleozoic

Rocks tentatively referred to the Paleozoic are sparsely distributed within the area. Several formations of different ages may be present; three groups based on lithologic dissimilarities are distinguishable. Two are quartzite, the other an altered limestone series. They have been grouped into one mapping unit because of their slight areal distribution and the small scale of the map.

Cambrian (?) Quartzite. In Bessemer Basin, on the northern side of the largest hill to the northwest of the playa, a low ridge about 100 feet wide extends to the northwest for approximately one-fifth of a

[7] Hulin, C. D., Geology and ore deposits of the Randsburg quadrangle of California, Cal St M Bur, B 95: 21-23 (1925)

mile. The ridge is composed of bedded quartzite which strikes N. 70° W. and dips 18° E. The exposure is surrounded by alluvium except near the eastern limit of the ridge, where a depositional contact upon dioritic rocks is exposed for less than 100 feet. The contact surface cut in the diorite shows only slight irregularities; it dips east parallel to the basal quartzite beds. Nearly 75 feet of quartzite are exposed.

Lithology: The quartzite is red-brown on the weathered surfaces, well-cemented, and partially recrystallized. The average grain size is between four and six mm. Sporadic rounded and sub-rounded chert and jasper pebbles, which range in size from one to three cm., are prevalent near the base; scattered lenses occur throughout the section. Single beds, commonly of even thickness, range from three to four inches. Cross-bedding on a small scale is frequently observed, being most easily visible on weathered surfaces. Upper beds truncate the underlying cross-beds, the inclined planes of which dip at angles of 10° to 15° to the overlying bedding planes.

Microscopically, the quartzite is composed of interpenetrating grains of quartz; the rounded, occasionally elliptical granules of the pre-existing sandstone are outlined by borders of finely divided sericite and ferric oxide. Regrowth of the grains has taken place by addition of silica or by recrystallization. Sericite is the only indication that feldspar was once present; no feldspar was seen in this section.

The quartzite was originally a sandstone, formed in part by deposition in water, and in part by wind action.

Correlation: The lithologic character and the basal unconformity place this quartzite as the probable equivalent of a part of the Cambrian quartzite in the Marble Mountains.[8] The Arrastre quartzite[9] in the San Bernardino Mountains is perhaps the equivalent of the quartzite in Bessemer Basin. However, the base of the Arrastre is not exposed, and the evidence for such a correlation is poor. A notable resemblance is seen when the Bessemer Basin quartzite is compared with the description of the Lower Cambrian Campito sandstone of the Inyo Mountains.[10]

Saragossa Quartzite. Outcrops of Saragossa quartzite occur in the northern portion of the Fry Mountains and on the southwestern flank of Bessemer Mountain surrounded by granitic rock or bounded by alluvium. The large body which outcrops on Bessemer Mountain is intruded by meta-porphyry and by quartz monzonite of the Ord Mountain group. On the north side of Red Hill, at the northeastern border of the Fry Mountains, nearly 360 feet of beds are exposed. The base has been destroyed by an intrusion, so that the total thickness is not determinable.

Depositional bedding planes are very poorly preserved, but when distinguishable indicate even bedding. Individual beds range from four to ten inches in thickness. Occasional small-scale cross-bedding shows that current action was present during the deposition of the beds.

Lithology: The quartzite is fine-grained, dense, massive, and sugary in appearance. Surface colors are red, pink, brownish-black (desert varnish), gray, and white. Pyrite cubes, disseminated throughout a portion of the quartzite, weather to limonite and hematite, showing pink and reddish stains. Both pyrite and the residual iron oxides are localized along fractures and bedding planes. Aside from the pyrite, the quartzite consists almost entirely of round to sub-round, well-sorted quartz grains, which range in size from 0.05 mm. to 1.0 mm., averaging 0.8 mm., with sporadic grains up to 1.5 mm. in diameter. Many of the grains show later quartz in optical continuity with the original grains, which are outlined by a discontinuous coating of micaceous flakes. In most instances, however, the silica growth is of slight importance, the rounded grains being distinct and enclosed in a sericite-muscovite 'paste' derived from a clay or kaolin-rich coating. The grains

[8] Hazzard, J. C., and Crickmay, C. H., *op. cit.*, pp. 59-61.

[9] Vaughan, F. E., *op. cit.*, pp. 352-354.

[10] Knopf, A., and Kirk, E., A geologic reconnaissance of the Inyo Range and the eastern slope of the Sierra Nevada, California. USGS, PP 110: 27-28 (1918).

acquired this coating when deposited, or soon after, indicating that the action of wind was not a factor in the accumulation of the beds. The quartzite is of aqueous origin, possibly marine, despite the perfection of the sorting, the heavy quartz concentration, and the fine size of the grains.

Correlation: The quartzite occurring in the Fry Mountains and on Bessemer Mountain is similar in lithology and field appearance to the Saragossa of the San Bernardino Mountains.

In the San Bernardino Mountains the Saragossa quartzite has been described as lying conformably above the Furnace limestone.[11] In a later paper, the Furnace limestone[12] has been assigned to the Mississippian (?) on the basis of scanty but definite fossil evidence. "The fossil bed appears to be nearly horizontal, and hence is probably close to the top of the formation stratigraphically. . . ."[13] If this is the case, and Vaughan's determination of the relationship between the Saragossa quartzite and the Furnace limestone is accepted, the Saragossa quartzite is probably of upper Paleozoic age, although the possibility of a Mesozoic age can not be ignored.

Undifferentiated Marbles and Quartzites. Marbles and quartzites, tentatively referred to the Paleozoic, occur on the northern border of the Fry Mountains along the crest of Camp Rock Ridge. The trend of the outcrop is northwest, and the general strike is parallel to this trend, roughly N. 40° W. The beds dip to the southwest at angles ranging from 25° to 85°. Quartz monzonite intrudes the unit along the southwestern base of the ridge, while tongues of quartz monzonite extend up into the marble and quartzite nearly to the ridge crest. Saragossa quartzite outcrops on the eastern side of the ridge. While it appears to underlie the marbles, the relationship is uncertain; the contact is either faulted or complicated by quartz monzonite and rhyolite intrusion along the contact plane. A possible maximum thickness of 490 feet is shown in a section taken near the southeastern end of the ridge.

Lithology: The series consists of interbedded marbles and quartzites with associated garnet and diopside-garnet rocks. The marble is gray to buff in color, with a fine-grained, even-granular texture. The rock consists of equal amounts of crystalline calcite with small anhedral and subhedral grains of diopside. Tremolite is also developed. Quartzite, commonly greenish in color, but in some instances buff or white, is composed of interpenetrating anhedral quartz grains. In the greenish varieties an amphibole, perhaps pargasite (?), occurs as wisps, shreds, and radiating fibers, generally along the boundaries of the quartz grains, but occasionally included within them.

Dense, fine-grained garnet rock occurs as a belt about 150 feet thick, striking parallel to the ridge along the crest. The rock consists almost entirely of brown garnet, a part of which is isotropic with anhedral form; the larger portion is anomolous garnet which is intricately twinned with included grains of diopside. The rock mass is cut by lines of fracture which have been infilled with calcite, or, in the diopside-garnet rock, by diopside. Epidote and quartz veins are also found cutting the garnet rock or the other members of the series.

Correlation: The series is intruded by quartz monzonite of Jurassic (?) age and apparently overlies the Saragossa quartzite, suggesting that it is either younger than, or represents higher beds within, the Saragossa. No fossils were found.

Triassic—Ord Mountain Group

The name *Ord Mountain group* is proposed for the rocks which outcrop on Ord, East Ord, and Kane Mountains, and on the southern flank of Bessemer Mountain. The character of the whole group, com-

[11] Vaughan, F. E., *op. cit.*, pp. 357-364.

[12] Woodford, A. O., and Harris, T. F., Geology of Black Hawk Canyon in the San Bernardino Mountains, California. Cal Univ, Dp G, B 17: 268-271 (1928)

[13] Woodford, A. C., and Harris, T. F., *op. cit.*, p. 270.

pared with the other rocks of these regions, is distinctive. The rocks are associated with each other areally, are of similar age, and are intruded by Jurassic (?) plutonics. Consequently, the name is valuable in designating a distinctive rock assemblage in this portion of the Mojave Desert.

The Ord Mountain group is divisible into two major units, which are capable of further subdivision. From oldest to youngest the major units are: (1) andesitic flows, tuffs, and breccia, and (2) hypabyssal intrusive rocks with a porphyritic habit, termed *meta-porphyry*.

Extrusive Rocks

Andesitic Lava and Tuff. The lava and tuff of the Ord Mountain group outcrop on Ord Mountain and on Kane Mountain. The rocks are best exposed and the field relationships most clearly discernable on Ord Mountain, where the rocks of the group outcrop over an irregular area which extends about a mile and a half north and south of the summit, and about two miles west from the summit. The unit is intruded along the eastern and southern boundaries by meta-porphyry of the Ord Mountain group. This intrusive relationship is well shown in the canyon south of the summit; lavas form the roof and northern wall, against which the meta-porphyry has chilled. The contact surface is horizontal beneath the roof, but steepens to the north, until a maximum observed dip of 45° N. is reached, near the bottom of the canyon. A fault zone, striking N. 15° W. to N. 5° E., and dipping 60° to 70° E., forms the western border of the lavas, separating them from the quartz monzonite. Included fragments similar to the lava rocks are found in the quartz monzonite south of the fault zone; but a definite intrusive contact is absent in this locality. However, in the saddle near the head of East Ord Basin, small masses of lavas of the Ord Mountain group are intruded by a similar monzonite. Lying above and to the east of the fault zone, a bed of slate, apparently derived from andesitic tuff, is continuous along the general line of the fault for about half a mile. The slate beds are commonly in fault contact with the granitic rocks; in one locality they appear to grade into a rock resembling meta-porphyry, but retain irregular areas resembling slate.

Porphyritic lavas overlie the slate beds. An essential concordance is shown between indistinct lines of amygdules and the slaty cleavage, suggesting that the slaty cleavage is parallel to the original bedding planes of the tuff from which it has been derived. If such is the case, a thickness of 110 feet of tuff is exposed, overlain by lavas with an estimated minimum thickness of 1,800 feet.

Along the northern contact, the lavas are bounded by alluvium, while to the northwest the relationship to the quartz monzonite is indeterminable, the contact being faulted. However, fragmentary masses of lava are included within the quartz monzonite north of the fault contact.

On Kane Mountain a mile-wide belt of massive lava of the Ord Mountain group extends northeast across the summit of the western crest. The lava is intruded by meta-porphyry, irregular areas of which are present within the limits of the lava outcrop. Tertiary (?) acid dikes also cut the lavas.

Lithology: The extrusive rocks are massive. They are generally broken by three joint systems, one of which is more pronounced than the other two. Sometimes the lavas are amygdaloidal, with amygdules of quartz, calcite, epidote, celadonite (?), and infrequently, zeolites, which often weather out, giving a vesicular appearance to the rock. The mass of the rock is cut by small, ramifying quartz, calcite, and epidote veins.

The andesitic lavas are dense, compact, fine-grained rocks with a prevailing greenish to greenish-black color. Megascopically, small phenocrysts of plagioclase can be seen in a dark-colored, finely-crystalline to glassy groundmass. The rock consists of partially resorbed andesine or oligoclase phenocrysts (0-25%), which are commonly altered to mixtures of calcite, quartz, sericite, and epidote. Scattered augite and olivine phenocrysts (0-2%) are set in a hyalopilitic groundmass, in which felted irregular nets of andesine and oligoclase microlites (15-55%), and magnetite (0-5%) occur in a matrix of chlorite and devitrified glass (0-20%). Secondary minerals are chlorite (0-1%) and small amounts of calcite, quartz, epidote, sericite, and celadonite (?).

Andesite Breccia. This, the second member of the extrusive phase of the Ord Mountain group, outcrops in a roughly circular form about three miles in diameter, comprising the main body of East Ord Mountain. On the west and south flanks of the mountain the breccia is intruded by quartz monzonite, while on the east and northeast it rises abruptly from the alluvial fill of East Ord Basin. A small, irregular monzonite-porphyry body on the southeast flank of the mountain is intrusive into the breccia. Both are cut by Tertiary acid dikes.

The rock is massive with no sign of bedding or variation in composition or appearance throughout the mass, which is, however, broken by vertical joints.

Lithology: The breccia is dark gray to black in color, weathering to a dark gray; it consists of sub-angular to angular andesitic fragments enclosed in a fine-grained andesitic groundmass. The fragments are well distributed throughout the mass with no concentration of even-sized inclusions. On the contrary, all variations in size, from 0.1 mm. up to 10 cm. in diameter, are found in all localities. These fragments are present in all degrees of distinctness from mere dark blurs to sharply angular discrete blocks.

The matrix of the rock is porphyritic, with phenocrysts of partially resorbed orthoclase (10%) and plagioclase (11%) included within a finely crystalline intergrowth of feldspar microlites (60-65%), hornblende (3-5%), magnetite and apatite (1%). Chlorite and celadonite (?) occur as secondary minerals.

The included andesitic fragments are composed of small, lathlike oligoclase microlites set in a finely crystalline base in which finely divided magnetite is abundant.

The roughly circular outline of the mass, its homogeneous character, its content of andesitic blocks, and its prevailing vertical joint system, indicate that the breccia body is a volcanic neck or vent.

Intrusive Rocks

The intrusive rocks of the Ord Mountain group have been separated into three units; meta-porphyry, andesite porphyry, and monzonite porphyry. All three have been grouped into one mapping unit.

Meta-Porphyry. The meta-porphyry of the Ord Mountain group is exposed on Ord Mountain, on Kane Mountain, on the southeastern flank of Bessemer Mountain, and in the Southern Ord Mountains.

Typical exposures occur on the eastern and western sides of Kane Mountain as two northward-trending belts intrusive into lava which separates them. The meta-porphyry is intruded by quartz monzonite along the eastern border of Kane Mountain.

On Ord Mountain an irregular body of meta-porphyry extends nearly two miles east and about three miles north and south from the summit. The meta-porphyry intrudes the lava along the western contact, while to the east and south it is intruded by quartz monzonite. The intrusive contact is well exposed in the canyon lying southwest of the summit, where Ord Mountain lavas show as the roof and northern wall against which the meta-porphyry body has chilled. A finer grain-size is evident in the porphyry body near the contact, and a rough sheeting parallel to the contact surface has been developed. East of the summit, small masses of lava are included within the porphyry. In the saddle between Ord and East Ord Mountains, and in the monzonite to the north, meta-porphyry occurs included within the quartz monzonite.

In the Southern Ord Mountains there are two bodies of porphyry similar to the meta-porphyry; the most westerly, lying along the ridge dividing Stoddard Valley from upper Lucerne Valley, extends southeast along the ridge beyond longitude 116° 00′. At its eastern contact the meta-porphyry is intruded by granitic rocks; just east of the edge of the quadrangle an irregular tongue of Cactus granite cuts through the porphyry body.

On the southeastern flank of Kane Mountain, an irregular porphyry body, about 2½ miles from east to west and nearly one mile from north to south, has been intruded on the north by quartz monzonite and on the east by the Cactus granite. Along the southwestern contact the porphyry is intrusive into the Saragossa quartzite.

Lithology: The meta-porphyry is gray to black in color, porphyritic with feldspar phenocrysts set in a dense, black or gray, finely crystalline or microdiablastic groundmass. Zoned andesine (10-40%), orthoclase (0-30%), and quartz (0-15%) occur as blasto-phenocrysts surrounded by a groundmass composed of a fine, crystalline, granular intergrowth of quartz and feldspar (either orthoclase or plagioclase) with minor amounts of augite, magnetite, titanite, zircon, and apatite, any of which may be absent in any particular rock. Uralite, celadonite (?), and chlorite occur as secondary minerals with minor amounts of calcite, epidote, sericite, and quartz.

Plagioclase blasto-phenocrysts are constantly present. Orthoclase and quartz blasto-phenocrysts may both be absent, or both be present, or either one may occur alone. This variation is due either to variations in the original character of the porphyry, or to partial resorption of these minerals in certain localities during recrystallization.

This rock type might have been formed by the partial recrystallization of a porphyritic igneous rock with the rearrangement of the groundmass and the retention of the phenocrysts. Both relict and new textures seem to indicate such a history.

Andesite Porphyry. The andesite porphyry of the Ord Mountain group occurs as dikes in the eastern belt of the meta-porphyry on Kane Mountain. The dikes range in thickness from two to four feet and can be traced for over half a mile. They were not observed in contact with the quartz monzonite, but do occur cutting the Ord Mountain lavas on Kane Mountain. They are not mapped separately from other intrusive phases of the Ord Mountain group.

Lithology: Megascopically, the rock is porphyritic, with a fine- to medium-grained groundmass. Sharply euhedral andesine laths, with sparse tabular augite crystals occur in a diabasic groundmass consisting of scattered aggregates of euhedral plagioclase laths and needles with interstitial augite. Magnetite is also present. Secondary minerals are uralite, celadonite, and mixtures of calcite, epidote, sericite, and quartz.

Monzonite Porphyry. On the southern flank of East Ord Mountain, rising abruptly from the alluvium, a small, irregular body of monzonite porphyry intrudes the andesitic breccia of the Ord Mountain group. Because it is intrusive into the Ord Mountain group and its relationship to the plutonic rocks is unknown, the monzonite porphyry is included in the same mapping unit as the other porphyritic igneous rocks which intrude the Ord Mountain group. The porphyry is cut by dikes of Tertiary (?) quartz porphyry and also by younger basic dikes.

Lithology: The monzonite porphyry is light colored, yellowish in appearance, and weathers to a reddish brown. Ragged and partially corroded orthoclase (20%) and tabular equidimensional oligoclase (17%) phenocrysts occur in a fine-grained groundmass consisting of a crystalline granular intergrowth of quartz and plagioclase in equidimensional anhedral and subhedral grains. Small apatite crystals occur both in the groundmass and enclosed within the phenocrysts.

Correlation and Age of the Ord Mountain Group

The age of the Ord Mountain group is fixed as pre-late Jurassic (?), for rocks of the group are intruded by Jurassic (?) plutonics. The possibility of an Archean age can be eliminated, for the rocks lack the high degree of metamorphism characteristic of the Archean rocks, not only within this region, but in surrounding parts of the Mojave Desert. The possibility of a Paleozoic age can virtually be eliminated, for none of the Paleozoic sections in the surrounding regions show any indications of volcanic activity.

The group is considered to be either Triassic or Jurassic in age. Volcanic rocks, which have been considered to be of Triassic (?) age, are present in the Inyo Mountains [14] to the north, and in the Santa Ana Mountains [15] to the west.

Jurassic (?) Plutonics

Plutonic rocks, presumably related in time to the Nevadan revolution, are widespread within this region and outcrop over large areas. They range in composition from a granodiorite to an acid granite; quartz monzonite is the most common. The plutonics are divisible into four units separated by definite time intervals. From oldest to youngest these are: (1) hornblende-quartz monzonite of the Newberry and Fry Mountains; (2) granite of the Minneola salient and Daggett Ridge ("pink granite"); (3) biotite-quartz monzonite correlative with the Cactus granite,[16] and (4) quartz porphyry of the Sunshine Peak district. A fifth mapping unit—undifferentiated plutonics, of unknown and of different ages—was used in the Southern Ord Mountains, south of Bessemer Dry Lake, and in the northern Bristol Mountains.

Hornblende-Quartz Monzonite. Plutonics of this general type are areally the most important. They occur: (1) in the Newberry Mountains, east of Kane Springs; (2) in the Fry Mountains; and (3) surrounding the Ord Mountains.

In the Newberry Mountains, extending from Kane Canyon southeast to Bessemer Mountain, the massive quartz monzonite outcrops over

[14] Knopf, A., and Kirk, E., *op. cit.*, p. 48.

[15] Mendenhall, W. C., Southern California Triassic rocks southeast of Los Angeles. USGS, PP 71: 505-506 (1912).

[16] Vaughan, F. E., *op. cit.*, pp. 364-365.

an area about nine miles by four, intruding the meta-porphyry of the Ord Mountain group and the Saragossa quartzite, but intruded by the Cactus granite northeast of Bessemer Mountain. On the southwest the continuity of the monzonite body is broken by the Camp Rock fault; similar rock types reappear south of the fault to make up the main mass of the Fry Mountains.

The northern border of the monzonite is believed to be outlined by a fault extending east from Kane Canyon. Definite evidence of faulting along this general line is seen in the displacement of the rhyolite just south of the western tip of the Malpais flow. The fault is covered by alluvial fill but on physiographic evidence is considered to extend eastward.

Two blocks of monzonite lie north of the Malpais flow; though separated on the surface from the larger body to the south, they are believed to be parts of the same mass.

Although the plutonic rocks of the Fry Mountains show more variation than those of the Newberry Mountains, they are the same intrusive. The dominant rock type is a hornblende-quartz monzonite with irregular bodies of fine-grained diorite which also occur as streaky blotches, faintly elliptical, fading into the monzonite. Schlieren are oriented parallel to the gneissoid banding wherever the latter feature is present. The complex is intruded by dikes of Cactus granite, which compose about one-tenth of the mass along the eastern border; to the west, the number of dikes decreases and the surrounded blocks become larger. No such dikes are present along the western border of the Fry Mountains.

There are three main parallel ridges in the Fry Mountains, all trending northwest. Fry Ridge, the most southerly, is an uplifted block with an undulating summit area. This erosion surface slopes gently to the southwest. A second ridge, extending from Johnson Valley toward East Ord Mountain, is a tilted fault block with a similar surface showing on the back slope, dipping southwest at a low angle. A pronounced topographic break on the northeast side indicates the position of the fault line scarp. Camp Rock Ridge is the northern limit of the Fry Mountains, forming the southern border of the Camp Rock trough. The back slope descends into the basin north of the second ridge.

Large, irregular areas of hornblende-quartz monzonite outcrop discontinuously in the vicinity of Ord and East Ord Mountains, and in the upper reaches of Stoddard Valley. Outcrop areas are low, even ridges separated by alluviated valleys. The higher summit crests are composed of rocks of the Ord Mountain group, which are more resistant to erosive action than the softer, more easily disintegrated monzonite.

Petrology of the Hornblende-Quartz Monzonite: The rock is dark gray in color, with a massive appearance. The texture is hypidiomorphic-granular, fine- to coarse-grained granitic, or, rarely, slightly gneissoid; in some instances a porphyritic facies is found, in which euhedral orthoclase phenocrysts, averaging two inches in length, are enclosed in a medium-grained to granitic groundmass.

Orthoclase (20-55%), acid plagioclase (15-45%), and quartz (10-20%) occur as essential constituents, with hornblende (6-10%) and biotite (0-10%) as accessories. Titanite, magnetite, apatite, and zircon are also present. Secondary minerals are chlorite, kaolin, sericite, quartz, and epidote.

Schlieren and Larger Inclusions: A characteristic feature of the quartz monzonite is the occurrence of scattered inclusions and schlieren of fine-grained diorite. The latter are more common in the Newberry and northern Fry Mountains; the larger inclusions are frequently found in the Ord Mountain region and southern Fry Mountains.

These schlieren and inclusions range in size from scores of feet down to inches in diameter. Often only slight concentrations of ferro-magnesian minerals indicate their former presence. All are dissimilar in composition from the enclosing rocks; they appear to represent fragments of fine-grained diorite which have been included within the quartz monzonite, partially digested and altered. The schlieren are elliptical in cross-section, generally with irregular boundaries grading into the enclosing monzonite; sometimes the boundary surface is sharp and distinct. The matrix surrounding the inclusions seems to be slightly more basic than the mass as a whole.

Granite. The granite of Jurassic age is found in two localities: (1) as irregular outcrops along the northern front of the Newberry Mountains, west of Newberry Peak, and as exposures surrounded by Tertiary lava, south of Newberry Peak; (2) in the northern Bristol Mountains.

Two small areas of granite outcrop on the western side of Newberry Peak. The larger of the two, an elongated body with included xenoliths of gneiss, is overlain along the eastern contact by Red Mountain andesite flows which dip east parallel to an erosion surface on the granite.

South of Minneola the granite occurs discontinuously. It is overlain by alluvium or volcanics, which rest upon an erosion surface cut in the granite. The contact with the Tertiary lava on the southeast is faulted; the lava and sediments dip southwest and abut into the granite along the strike. The basal member of the section rests with erosional unconformity on the same granite near the base of Minneola Ridge.

Daggett Ridge, an irregular granite block about four miles long and two miles wide, is uplifted by an east-west fault along the northern edge. The granite is intrusive into Archean (?) diorite gneiss, and is overlain by Red Mountain andesite, Daggett lake beds, and Quaternary alluvium.

Immediately west of Daggett Ridge outcrop, a small area of granite with an inclusion of Archean (?) diorite gneiss has been emplaced by faulting. It is overlain unconformably by andesite agglomerate of the basal Rosamond (?).

Southwest of Basalt Peak, in the Newberry Mountains, two small granite outcrops occur as windows surrounded by Tertiary (?) lava or gravels.

The granite is exposed over an area about ten miles long and six miles wide in the northern portion of the Bristol Mountains. It is intrusive on the north into a diorite body; masses of fine-grained diorite up to a mile in length are included within it. East-west faults, which cut the mass, have been offset by northwest-trending faults. Along the southern border, the granite is overlain with erosional unconformity by Tertiary sediments and volcanics.

Petrology of the Granite: The term "pink" or "red" granite has been applied to the granite because of the distinctive reddish color which is especially apparent on weathered surfaces. The texture ranges from fine- to coarse-grained hypidiomorphic granular. The rock consists essentially of quartz (25-35%), orthoclase (40-45%), and acid plagioclase (10-25%) with scanty biotite (0-4%) and small amounts of apatite, titanite, and magnetite. Secondary minerals are chlorite, kaolin,

sericite, quartz, and limonite. Perthite is sometimes found. In all cases, the light-colored constituents compose about 95% of the rock. The scarcity of biotite and the practical absence of other dark minerals suggest alaskite as a group term; some facies do approach alaskite in composition.

Cactus Granite. The Cactus granite, which is the youngest plutonic rock exposed in the area, was first described and named by Vaughan [17] from its typical exposures on Cactus Flat in the San Bernardino Mountains. Within the Newberry Mountains the granite digresses in character from a true granite, and in many cases closely approaches a quartz monzonite in composition. A distinctive feature of the Cactus granite is the prevalence of aplite and pegmatite dikes, striking in various directions throughout the mass; due to the ease of disintegration of the granite, these dikes are left projecting above the surface, often giving an erroneous idea of the character of the bed rock. The granite outcrops in and around Johnson Basin, and in the Newberry and Southern Ord Mountains.

Many of the ridges surrounding Johnson Basin are composed of Cactus granite; the granite often outcrops along the base, and dikes of granite penetrate into the rocks of the ridge. Such is the case along the eastern and southeastern border of the Fry Mountains, where hornblende-quartz monzonite is intruded by ramifying dikes of Cactus granite. Areas of granite along the southeastern border of Johnson Basin are continuous with areas which Vaughan maps as Cactus granite south of latitude 34° 30′. Johnson Basin is believed to be underlain by a large body of granite which continues to the north across the Camp Rock trough into the Newberry Mountains. This is indicated not only by the areal distribution of the Cactus granite, but by the residual character of the alluvium, and by the presence of a surface, cut in the granite, which pitches south into the basin across the Camp Rock trough.

North of the Camp Rock trough a belt of Cactus granite, about eight miles long and slightly more than two miles wide, extends northward between Bessemer Mountain and Iron Ridge, to the fault contact with the Tertiary sediments south of Box Canyon. Arms dividing from this belt continue northwest to Old Road Canyon and northeast to the divide between Little Wonder Ridge and Sunshine Peak. Along the eastern border of this belt, the Cactus granite is intrusive into Archean (?) plutonics, while to the north it is terminated by faulting. East and north of Bessemer Mountain, the granite intrudes the Ord Mountain meta-porphyry, the Saragossa quartzite, and the horneblende-quartz monzonite.

West of Kane Mountain, about two miles south of Kane Springs, an elongated body of Cactus granite occurs along the bottom of Kane Canyon. It intrudes the Ord Mountain meta-porphyry and Archean diorite, and is overlain in part by gravels of post-Black Mountain basalt age.

About eight miles from Daggett, east of the Daggett-Ord road, a roughly circular outcrop of Cactus granite, about five miles long and two miles wide, occurs; it is unconformably overlain by Red Mountain andesite and by a sedimentary series which is possibly an eastern continuation of the Daggett lake beds.

[17] Vaughan, F. E., *op cit.*, pp. 364-365.

South of East Ord Mountain and north of Lucerne Valley, an irregular body of Cactus granite, about five miles long and two miles wide, occurs. On the southwest and south, pediment-like surfaces have been developed. The northern border is outlined by faulting.

On the southern border of Stoddard Valley, irregular discontinuous bodies of Cactus granite occur. The most northerly, which is intrusive along the contact between plutonics and meta-porphyry, appears to represent the tip of a stock-like body that widens in depth, for the contacts dip outward.

Petrology of the Cactus Granite: The Cactus granite is white on fresh surfaces and at a distance. Locally, iron stain causes a rusty appearance. The rock texture ranges from coarse- to medium-grained hypidiomorphic granular with local porphyritic facies, containing large euhedral orthoclase phenocrysts set in a medium-grained granitic groundmass. Essential minerals are quartz (15%), orthoclase-microcline (35-40%), oligoclase (30-35%), with euhedral biotite (8-10%) as the only accessory. Magnetite, apatite, and titanite are constantly present. Secondary minerals are chlorite and minor amounts of sericite, quartz, and kaolin.

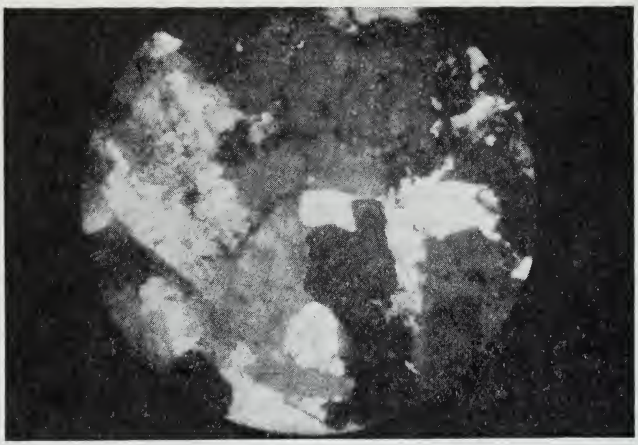

FIG. 3. Photomicrograph of Cactus granite (quartz monzonite) from the quarry in Lucerne Valley. Orthoclase and quartz appear with mutual boundary relationships; plagioclase is subhedral.

Quartz Porphyry. A description of this rock type, as it occurs on Sunshine Peak near the Imperial Lode mine in the Lava Bed mining district, is given by Storms [18] in conjunction with a report on the mines operating in the region.

Massive quartz porphyry outcrops in three localities within the area: (1) Sunshine Peak, (2) Little Wonder Ridge, and (3) south of Ludlow.

The main mass of Sunshine Peak consists of quartz porphyry, the body being slightly over six miles long and averaging close to three miles in width. It is apparently a block uplifted along the Newberry fault zone. The massive body is cut by dikes of orthoclase and plagioclase phenocrysts set in a fine-grained groundmass. Rare basic dikes occur. Silicified and mineralized faults and veins also break the quartz porphyry. The Imperial Lode mine is located along the largest of

[18] Storms, W. H., Los Angeles, San Bernardino, San Diego counties. Cal St M Bur, St Mineralogist's Rp 11: 349-350 (1892)

these veins, which outcrops as a rude, silicified wall of brecciated porphyry nearly five miles in length, striking N. 60° W., and dipping 72°-78° S. While the main mass of the porphyry is homogeneous in character and massive in appearance, local areas and zones are well brecciated and either silicified or hydrothermally altered to white, yellow, or red-brown amorphous kaolinized material showing remnant quartz phenocrysts. The rock mass is characteristically broken by two highly inclined joint planes; a third, nearly horizontal, is sometimes discernable.

In the southern portion of Little Wonder Ridge an irregular porphyry body, about 1½ miles long, intrudes the Cactus granite. On the east it is unconformably overlain by Tertiary (?) gravels and volcanics.

Two bodies of quartz porphyry occur a few miles south of Ludlow. The most southerly, in the vicinty of the Pacific mine, is about four miles long by two miles wide. It appears to be overlain by Tertiary volcanics. Over a large area, near the Pacific mine, the porphyry has been altered by hydrothermal action. The northern body, roughly elliptical in form, is overlain by volcanics.

Petrology of the Quartz Porphyry: The quartz porphyry is commonly gray to greenish-gray in color, although a purple or brown tinge is sometimes evident. In all instances the rock is porphyritic. Milky oligoclase-andesine (20-30%), cloudy orthoclase (5-20%), corroded quartz grains (5-20%), subhedral hornblende (5-10%), and biotite plates (2-5%), occur as phenocrysts inclosed in a fine-grained microgranitic groundmass. Both hornblende and biotite have been chloritized and occur as mixtures of penninite, epidote, and calcite. The groundmass of the rock consists of orthoclase (20-30%), quartz (10-15%), and plagioclase (5-10%), with minor amounts of magnetite and apatite. Secondary minerals are penninite (7-15%) with small quantities of epidote, calcite, colorless chlorite, green chlorite, and kaolin.

Undifferentiated Plutonics. In many localities and over considerable areas, plutonic rocks, of unknown and perhaps different ages, occur. These have been grouped into one mapping unit with other areas of granitic rocks in which the intimate mixture of types prohibits detailed separation on a map of the scale used. The unit was found (1) in the Southern Ord Mountains, (2) south of Bessemer Basin, and (3) in the northern Bristol Mountains.

Plutonic rocks crop out over an irregular area in the Southern Ord Mountains, surrounded and penetrated by broad alluviated valleys. Within this area, the most prevalent rock type is "yellow granite," often gneissoid, which includes many bodies of diorite, generally scores of feet in length, but ranging from small schlieren up to discrete bodies half a mile long. Both rocks are cut by dikes of pegmatite. The "yellow granite" appears to intrude the meta-porphyry of the Ord Mountain group, but its relations to other granitics within the region are not clear. It is similar in some respects to the Cactus granite, which in one locality apparently intrudes the "yellow granite." Faulting masks its relation to the hornblende-quartz monzonite.

Petrology: The "yellow granite" is fine- to medium-grained hypidiomorphic granular, or gneissoid, showing roughly parallel bands of quartz, orthoclase, and plagioclase separated by narrow, discontinuous bands consisting of fine-grained biotite and small amounts of hornblende. In the granitic facies, quartz and orthoclase occur in nearly equal quantities, with small amounts of microcline and plagioclase. Scanty magnetite and bleached biotite also occur.

The diorite is dull black in color, especially on weathered surfaces. The texture is fine-grained granitic, although gneissic facies are present. The rock

consists chiefly of plagioclase with hornblende and biotite. A porphyritic phase shows dull spots of hornblende in a fine-grained, even-granular groundmass of plagioclase, hornblende, and biotite.

A monzonite body outcrops south of Bessemer Basin in small fault blocks surrounded by alluvium. The monzonite is apparently intruded by Cactus granite in one locality south of Bessemer Dry Lake. Because the monzonite is closely similar petrologically to the hornblende-quartz monzonite, and has the same relation to the Cactus granite, it may be a variant of the Jurassic plutonics. However, from the known data such a conclusion can not be drawn without a chance of error.

Petrology: The rock is pinkish-gray in color, weathering to a dark gray. The texture is medium-grained hypidiomorphic granular with quartz (25%), orthoclase (25%), and oligoclase (20%) as essential minerals. Hornblende and biotite are the accessories. Titanite is also present.

Massive diorite and diorite gneiss of unknown age outcrop in the northern Bristol Mountains. The mass is intruded on the east by granite similar to the "pink granite."

Petrology: The rock is generally dark gray in color, with a coarse-grained granitic texture; hornblende and plagioclase in nearly equal amounts are essential constituents, and biotite occurs as an accessory. The coarse gneissic variants are developed from the diorite by re-orientation of the minerals with no observed development of new minerals.

Origin and Age Relations of the Plutonics. The plutonic rocks of this group are related to each other in that they are units composing a batholithic mass; relations between them indicate time intervals between the emplacement of the different units.

No definite conclusion is evident regarding the age of the plutonics from occurrences or field relations within the area. They are intrusive into Paleozoic, possibly upper Paleozoic, sediments, and also intrude the Ord Mountain group, which may be of Triassic age. Tertiary rocks rest upon an erosion surface cut in the granitics.

Plutonic outcrops continue across the southern border of the region under consideration and extend into the San Bernardino Mountains. These rocks have been described and referred to the Jurassic (?).[19] If the plutonics of the Perris block [20] can be correlated with those of the San Bernardino Mountains, a stepping stone is established into the Santa Ana Mountains, where definite evidence of the pre-Cretaceous age of the plutonics is found, establishing a fabric of presumptions indicating the correlation of the plutonic rocks of the Newberry and Ord Mountains with those of the Nevadan revolution.

In the Mojave Desert region to the east, granitic rocks occur in the Marble Mountains. They are intrusive into the Goodsprings formation [21] and possibly are of Jurassic age. To the north, in the Randsburg quadrangle, the Atolia quartz monzonite is considered to be related to the time of the Sierra Nevada revolution, and thus to be of Jurassic or early Cretaceous (?) age.[22] Although the entire question of the time of the Nevadan revolution remains in debate at present, the younger plutonics, in this and adjacent portions of the Mojave Desert

[19] Vaughan, F. E., *op. cit.*, pp. 364-374.

[20] Dudley, Paul H., Geology of a portion of the Perris block, southern California. Cal Jour Mines and Geol, St. Mineralogist's Rept. 31: 501-505 (1935)

[21] Hazzard, J. C., *op. cit.*, pp. 59-60.

[22] Hulin, C. D., *op. cit.*, pp. 32-42.

region, are related to it in time, and thus may be considered to be of Mesozoic age.

Tertiary and Quaternary Rocks

General Features

The preceding types and groups of rocks are considered to compose the basement complex; the last units are the Jurassic plutonics. Following these granitic intrusions there must have been a long period of erosion during which the upper cover was stripped from the granite over large areas. The thickness of the cover removed is not known, although it is believed to have been great. There is no record of deposition within the area during this time; exterior drainage probably carried the detritus to the south or west. During the erosion period, a surface, which may have approached a peneplain, was developed and remained undisturbed until middle or early Tertiary time, when it was broken up, and continental deposition began in interior basins.

The general sequence of events in this region during the Tertiary seems to be similar in a broad sense to the sequence observed in surrounding portions of the Mojave Desert: (1) Erosion during the early Tertiary, presumably with exterior drainage. (2) Destruction of the early Tertiary drainage systems and erosion surfaces, with the formation of a series of closed basins. (The exact positions of these basins are indefinable, but the general form and location can be ascertained in some cases.) (3) Intrusion of quartz porphyry dikes; intrusion of basic dikes; mineralization. (4) Deposition of fluviatile, lacustrine, and volcanic material with interbedded basic flows. These materials seem to be correlative with the Rosamond. (Relation of 3 to 4 not proved in this area.) (5) Eruption of agglomerates, tuffs, and flows of Red Mountain andesite. (6) Erosion, with the deposition of post-Red Mountain andesite gravels. (7) Extrusion of flows of Black Mountain basalt. (8) Erosion, with the deposition on the post-Black Mountain basalt gravels. (9) Deposition of the Daggett lake beds. (10) Deposition of the older alluvium. (11) Eruption of basalt flows of the Pisgah and Sunshine Peak areas. (12) Accumulation of recent alluvium, river wash, talus slides, rock mantles, and sand dunes.

Several periods of faulting are interspersed in the above sequence, but, as the exact position of each period is subject to some doubt, these will be considered later.

Dike Rocks

Acid Dikes. Acid dikes of probable Tertiary age cut the rocks of the "basement complex." They are especially prominent on Ord, East Ord, and Kane Mountains, but are also found in the Fry and Newberry Mountains, and in the Sunshine Peak and Ludlow quartz porphyry areas. These dikes range from two feet to several hundred feet in thickness, and can sometimes be traced for 2,500 feet along the strike. Mineralized shear zones and faults often offset these dikes.

Petrology: The rocks are light-colored, commonly porphyritic with a white or yellowish microcrystalline groundmass, sometimes showing fluxional effects. Orthoclase (15-25%) and oligoclase (2-10%) grains occur as phenocrysts included within a very fine crystalline to microcrystalline intergrowth of quartz (35-45%) and orthoclase (30-40%) with rare scattered grains of apatite, titanite, magnetite, and chlorite. Ferro-magnesian minerals and other dark-colored constituents are negligible.

Basic Dikes. Groups of basic dikes are common features of certain parts of the region and seem to be confined, roughly, to the mineralized districts, although solitary basic dikes occur in other localities. Wherever the relationship between the acid and basic dikes is determinable, the latter are the younger. In the mineralized districts the basic dikes were injected prior to mineralization. These rocks are especially prominent in the Ord, East Ord, and Fry Mountains. They also occur in the Newberry Mountains.

Petrology: The dike rocks are generally holocrystalline, dark gray to black in color. In other instances they are porphyritic with black aphanitic groundmass. They are composed of plagioclase, hornblende, magnetite, and indeterminate groundmass material.

Origin and Age. The close relationship of the acid and basic dikes is indicated by the occurrence of both in the same areas, the basic always cutting the acid dikes. Both are offset along mineralized shear zones and were injected prior to the mineralization. While they intrude the granitic rocks and the Ord Mountain group, they are not in contact with the Tertiary sediments in this area, and no detritus from them was recognized in the Tertiary sections.

In the Randsburg quadrangle [23] to the north, definite evidence of the middle Tertiary age of both the acid and basic dikes is available. No such evidence was seen within this area, but these dikes may be of similar age.

FIG. 4. Rosamond (?) sediments and volcanics in Old Road Canyon, Newberry Mountains. The gravel cappings in the background are the post-Red Mountain andesite gravels, which overlie the Rosamond (?) unconformably.

Rosamond Series

All determinable Tertiary sediments and volcanic material, prior to the Red Mountain andesite, have been grouped into one mapping unit which is correlated tentatively with the Rosamond series.[24] Within the limits of this area the series consists typically of coarse angular fanglomerates with sandstones, shales, and tuffs, associated with inter-

[23] Hulin, C. D., *op. cit.*, pp. 48-55.

[24] Hershey, O. H., Some Tertiary formations of southern California. Am G 29: 349-372 (1902).

bedded agglomerates and basic flows. While the relative proportion of volcanic material to the sedimentary detritus is variable in the different sections, in both the horizontal and vertical directions, this variability does not seem to be the result of any great difference in the physical conditions at the sites of accumulation.

Rocks referable to the Rosamond occur in the Newberry Mountains, south of Daggett, in the hills south of Minneola, and in Box Canyon. In the Cady Mountains, north of the National Old Trails Highway, a thick volcanic section, which has not been examined, appears to contain at least a portion of this series. North of Sunshine Peak, and in the middle and southern portions of the Bristol Mountains, agglomerates, sediments, and volcanics perhaps equivalent to the Rosamond occur.

The series overlies the basement complex, and is overlain generally with angular unconformity by the Red Mountain andesite. The base, wherever it is exposed, is typified by the profound erosional unconformity which exists between the Tertiary and the pre-Tertiary rocks. The Rosamond is not necessarily present, and younger volcanics or sediments often rest upon the basement complex.

Within this area, the Rosamond is divisible into two distinct members: (1) basal agglomerate and (2) basic flows and gravels with interbedded tuff and sandstone.

Agglomerate. Three of the Tertiary sections are characterized by a gray-green agglomerate at the base. Locally this unit may be absent, but it commonly occurs ranging from 200 to 400 feet in thickness. Generally it rests upon the granitic rocks, although gravels are found beneath it in the Basalt Peak section. Overlying the agglomerate, gray gravels and basalt flows occur.

The agglomerate is present in the Newberry Mountains at the base of the sections from Basalt Peak west to Daggett Ridge. It is present also in the Box Canyon area, but elsewhere in the Newberry Mountains, east of Box Canyon, it is not known to occur. A similar unit is found in the Bristol Mountains near the base of the section, and it may be present in the Cady Mountains.

The agglomerate consists of partly rounded and angular fragments and boulders, six to eight inches in diameter, with many smaller ones, haphazardly scattered in a tuffaceous matrix. The unit as a whole is massive, unbedded, and presents a uniform appearance. The average percentage of boulders to the matrix is on the order of 1:1.

Petrology: The matrix is light grayish-green in color, consisting of angular fragments of crystalline material (chiefly broken labradorite crystals, with fragmentary augite, brown hornblende, and magnetite), embedded in a glassy base. The partial chloritization of the groundmass in restricted areas has resulted in the green coloration.

The boulders are composed of a rock that is porphyritic, with phenocrysts of labradorite and augite enclosed within a glassy groundmass in which occasional indeterminate plagioclase microlites occur. Augite phenocrysts are partially altered to hornblende and are frequently surrounded by borders of iron oxide.

Basic Flows and Gravels. In all sections in which the green agglomerate is present, it it overlain by a series of gravels and interbedded basic flows. Volcanic material occurs intermittently in the sections; generally several flows are combined together, preceded and followed by volcanic quiescence, during which sediments buried the underlying volcanics.

The gravels are composed of angular to sub-angular detritus occurring in massive beds which range from 5 to 150 feet in thickness. The size ranges, degree of sorting, constituents, and angularity are variable between the different beds. The sorting commonly is very poor, with fragmentary material, ranging from $\frac{1}{4}$ inch to 24 inches, and averaging six to eight inches, occurring in the same bed. The chief constituents in order of abundance are: granite, greenstone, meta-porphyry and hornblende-quartz monzonite. Other rocks of the basement complex also occur. The minor details of bedding are complex; lenticularity and rapid lateral variation in size ranges are distinctive features.

Interbedded with the gravel members and in Box Canyon, coarse- to fine-grained sandstones are found, which comprise a considerable portion of the section. They are composed chiefly of angular fragments of quartz and feldspar. Occasionally, beds of tuff and tuffaceous sandstones are associated with them.

The basic flows range from single flows 30 feet thick up to units consisting of many flows 500 feet or more in thickness. Most are red-brown to dull gray olivine basalts; others appear to be andesites. Locally, no olivine is present in the basalts.

Petrology: The rocks are typically porphyritic with phenocrysts of plagioclase (5%) and olivine (0-10%) enclosed in a hyalopolitic, sometimes trachytic, groundmass consisting of lath-like plagioclase (75%) with sub-hedral grains of olivine (10%) and augite (10%). Magnetite and brown basic glass, often slightly devitrified, occur interstitial to the groundmass crystals. Olivine is commonly altered to iddingsite.

Partial sections of the Rosamond are exposed within the area in many localities. Fairly complete sections occur on Daggett Ridge, Basalt Peak, and in Box Canyon, within the Newberry Mountains. In the northern Bristol Mountains, a fair section occurs. The accompanying correlation chart indicates the possible relationship of the different units in the various portions of the quadrangle.

In considering the sections at the different localities the most striking features are: (1) Lateral variation in thickness within short distances. (2) The base, if exposed, is characterized by a profound erosional unconformity. (3) Green agglomerate occurs at or near the base in all except the Daggett Ridge section. (4) Gray gravels occur below the agglomerate horizon in the Basalt Peak section. (5) Basic flows with interbedded gravels and sands occur in all sections. (6) Sandstone, shale, and conglomerate are present with only a slight break above the topmost lava member in the Box Canyon section. (7) Red Mountain andesite overlies the basic flows and gravels in three sections; elsewhere it is absent. (8) Black Mountain basalt is the last unit in five of the sections, in three of which there is either a strong suggestion or proof of an angular and erosional break at the base of the flows. (9) Similar sequence of events occur over a wide area. (10) Fossils are apparently absent.

Origin. The Rosamond sediments occurring in this area appear to be of continental origin, deposited along the flanks and in the basins surrounding the high-standing areas existent within the region at that time. That is, they are of local origin, and were deposited as alluvial fans and cones near the source rocks which are not far distant from the present position and outcrop of the beds. Lava flowed down over

the alluvial fans of Rosamond time and covered the cones with flows that were later buried under detrital material.

Correlation and Age. The term *Rosamond formation* was first used in literature by Hershey [25] to apply to the type section, which consists of a series of sandstones, interbedded tuffs, and rhyolite, outcropping near Rosamond station in the Elizabeth Lake quadrangle. The term has been extended eastward in the Mojave Desert to include beds of similar rocks. Indiscriminate use of the term Rosamond has resulted.

Mammalian fossils have been found and described from the beds of the Barstow syncline, north of the town of Barstow; the fauna is considered to be upper Miocene in age.[26]

The Rosamond series in the Randsburg quadrangle is considered to be upper Miocene. It consists of a continental series of "stratified conglomerate, feldspathic sandstones and clays." [27] These beds overlie the basement complex and are younger than the Red Mountain andesites which rest, generally with angular unconformity, upon them. This is strikingly similar to the mode of occurrence in the Newberry Mountains; however, as no fossil evidence is available in either area, the upper Miocene age is not conclusively determined.

In the Elizabeth Lake quadrangle, recent work, also not conclusive, indicates that the upper Miocene age is not final and a possible correlation with the middle Miocene is suggested.[28] This conclusion is reached by considering the relation of the Rosamond to the Escondido formation and to the time of the breakup of the pre-Tertiary erosion surface.

Red Mountain Andesite

Red andesite flows and yellow tuffaceous agglomerates provisionally correlated with the Red Mountain andesite [29] rest unconformably upon the Rosamond and upon the rocks of the basement complex.

Volcanic material which has been referred to this formation occurs in the Newberry Mountains and in the Lava Bed and Bullion Mountains. A large portion of the volcanic section in the Cady Mountains appears to belong to this unit.

Newberry Peak rising steeply 1,600 feet from the flat alluvial land of the lower Mojave Valley, is composed of massive red andesite and tuffaceous material. The flows rest upon an even granite surface, which dips southwest parallel to the basal lava beds. The main mass of the peak is broken by faults, many of large displacements, which on the north appear to step the lava below the valley floor. Locally the structure is complex, and consequently the thickness is not determinable with accuracy; but a probable maximum thickness of 1,200 feet is believed to be attained.

Elsewhere in the Newberry Mountains, scattered outcrops of Red Mountain andesite rest upon the basement complex, or occur as distinct

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[25] Hershey, O. H., *op. cit.*, pp. 349-372.

[26] Merriam, J. C., Tertiary mammalian faunas of the Mojave Desert. Cal Univ, Dp G, B 11: 437-585 (1919).

[27] Hulin, C. D., *op. cit.*, pp. 42-46.

[28] Simpson, E. C., Geology and mineral deposits of the Elizabeth Lake quadrangle, California: Cal Jour Mines and Geology, St Mineralogist's Rp 30:400-401 (1934).

[29] Hulin, C. D., *op. cit.*, pp. 55-58.

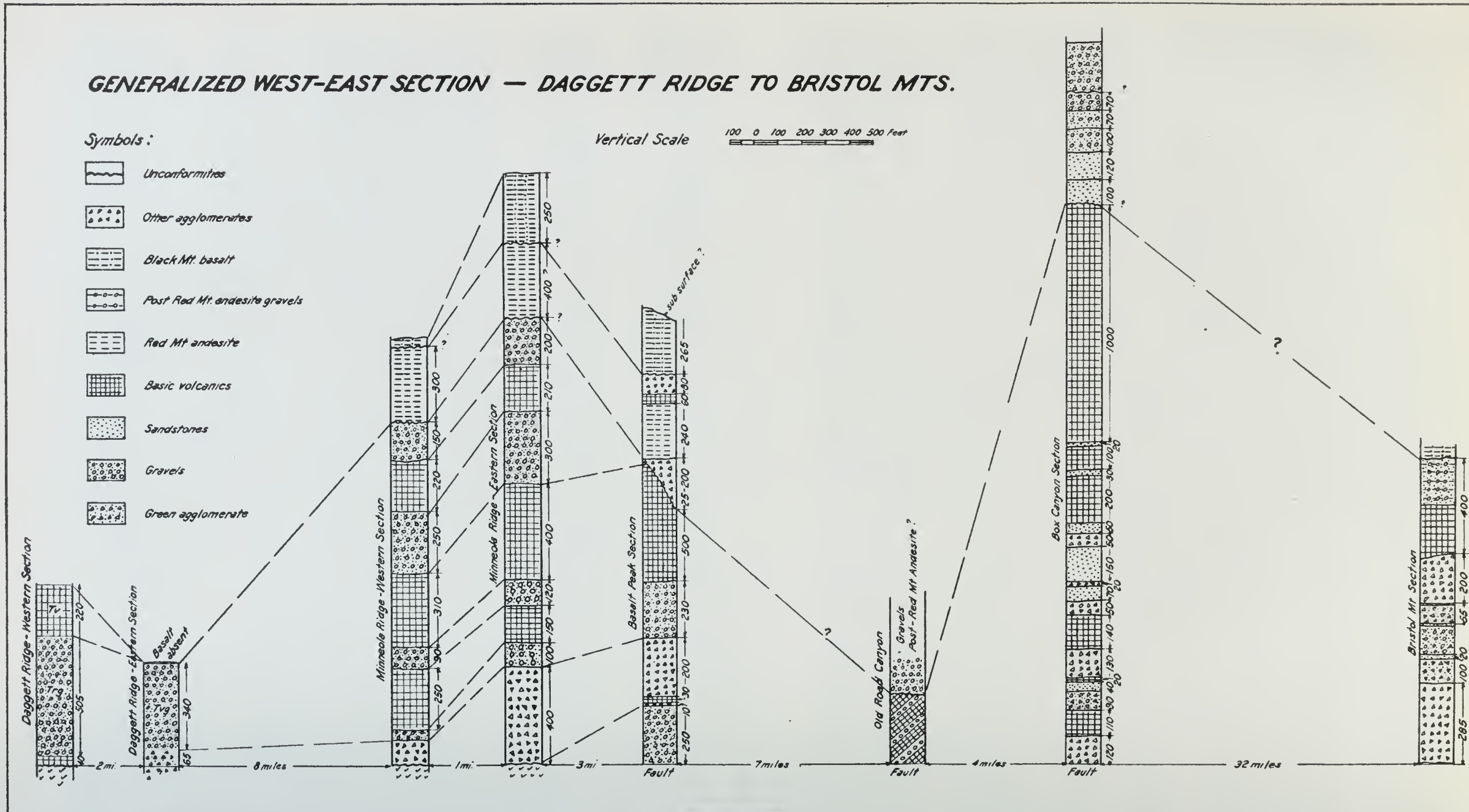

Fig. 5. Correlation chart of the Rosamond formation.

units in the Tertiary sections commonly overlying the Rosamond and overlain by Black Mountain basalt. These units range from 200 to 400 feet in thickness. Locally there are indications of erosion and canyon-cutting in the Rosamond prior to the eruption of these flows.

A small area of andesite on the southeast side of the Lava Bed Mountain is considered to belong to this formation. The northern portion of the Bullion Mountains consists of massive red andesite flows, tuffs, and agglomerates which are complexly broken by faulting.

The Red Mountain andesites are the result of localized fissure eruptions. Some of the fissures are filled by dikes; in most instances they are concealed. The pyroclastics indicate that explosive action was a factor in the formation of the andesites, but the location of the central vent has not been determined.

Petrology: The lavas of this group are distinctively red, with some reddish-brown, dark-gray, and black variations. The rock is usually porphyritic with abundant plagioclase phenocrysts and some biotite, hornblende, and augite, and rare quartz phenocrysts. The relative proportion of the phenocrysts to each other and to the groundmass is highly variable. The texture of the latter is glassy or microcrystalline. Frequently the groundmass is light-brown glass, although a finely crystalline net of feldspar needles and scattered magnetite grains with a glass matrix is not uncommon.

Interbedded with the lava flows are beds of yellow agglomerate and tuff. The agglomerates are composed of angular fragments of lava up to six inches in diameter, embedded in a tuffaceous yellow matrix. The tuffs are white or yellow in color, fine-grained, and consist of fragmentary feldspar, biotite, hornblende, and altered glass.

The mode of occurrence, the character, and the striking color ranges of the andesite within the Newberry Mountains are identical with similar features of the Pliocene Red Mountain andesite [30] in the Randsburg quadrangle, indicating a correlation in age between the two.

Post-Red Mountain Andesite Gravels

A series of gravels and sands resting upon Red Mountain andesite, Rosamond, and the basal complex, is overlain by Black Mountain basalt. This series outcrops in the Newberry Mountains, in the Lava Bed Mountains, and in other scattered localities.

Between Kane Canyon and Box Canyon along the northern front of the Newberry Mountains, a crudely bedded, massive series of gravels and sands rests, in most cases unconformably, upon the Rosamond. It is commonly in fault contact with the basement complex, and may rest upon it locally, although it is overlain and surrounded by basalt flow material. In Box Canyon immediately west of the road, the gravels rest upon the upturned truncated beds of the Rosamond. South of the road, light-colored, coarse gravels rest with apparent conformity, although at a slightly different dip, upon the Rosamond.

A sedimentary series composes the main mass of the Lava Bed Mountains; it rests unconformably upon the Red Mountain andesite and is overlain unconformably by Black Mountain basalt and by fanglomerates developed after the extrusion of these later flows. The section is complicated by strike faulting. It reaches a thickness of 900 feet.

[30] Hulin, C. D., *op. cit.*

Lithology: The gravels consist of poorly sorted angular to rounded fragments ranging in size from 6 to 10 inches on the average, although sporadic boulders up to 12 feet in diameter occur. The finer fragments are similar to the larger, and the lower limit of size is small. Bedding is generally poor and discontinuous, and a massive appearance is characteristic. The basement complex serves as a source for most of the fragments; Cactus granite, hornblende-quartz monzonite, quartz

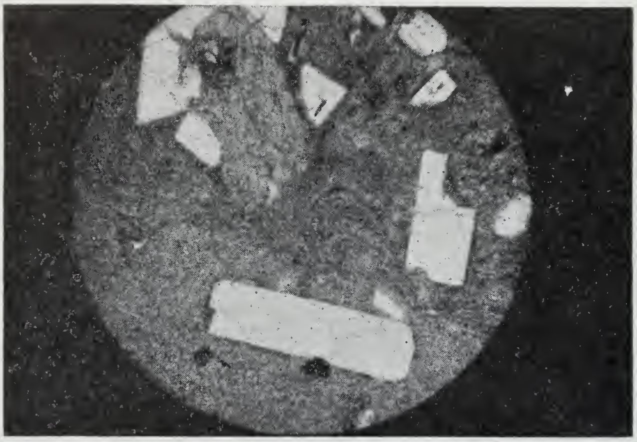

Fig. 6. Photomicrograph of augite andesite. The specimen is from a thin flow interbedded with Red Mountain andesite on Newberry Peak. Plagioclase and augite phenocrysts are set in a glassy groundmass. The matrix shows well-developed flow banding.

porphyry, and meta-porphyry are the most common. The Tertiary series is represented in smaller percentages by material from the Rosamond and from the Red Mountain andesite. No fragments were seen which could represent material derived from the Black Mountain basalt. The relative proportions of the detritus of the different types are variable.

Interbedded with the gravels, thin beds of sandstones with occasional shale beds occur. These are composed of angular to sub-round, poorly sorted fragments of basement complex and earlier Tertiary material.

The massive, poorly bedded character of the gravels, the extreme size ranges, and the high degree of angularity indicate that the unit represents accumulations of detrital material which were deposited as alluvial fans and cones.

As the sediments contain detritus from the Red Mountain andesite, no material from the Black Mountain basalt, and rest upon one, and are overlain by the other, they must be placed in the interval between the two periods of vulcanism. Though lacking fossil evidence, a possible Pliocene age is indicated.

Late Tertiary and Quaternary Basalt Flows

Basalt flows of this area are separated into two divisions which appear to be related, forming one major group with the occurrence of basaltic outbursts at different times, and in separate localities. The older flows are correlated with the Black Mountain basalt; the flows and cones of Mt. Pisgah and Sunshine Peak form a younger unit.

Black Mountain Basalt. The Black Mountain basalt flows occur extensively in the area. They are found in the Newberry Mountains,

Fry Mountains, Lava Bed Mountains, Bristol Mountains, and at other scattered localities.

Basalt flows cap the crests and extend down the back slopes of the ridges in the Newberry Mountains, on Basalt Peak, and in the vicinity of Minneola and Dagget Ridges. These flows commonly rest upon the Red Mountain andesite or the Rosamond and represent the uppermost member of the section. In some localities they are overlain by fanglomerates. The thickness of the unit ranges from 200 to 250 feet, being composed of 10 or 12 distinct flows averaging 20 feet in thickness.

The so-called "Malpais," in the central portion of the Newberry Mountains, was a flow of basalt erupted near Malpais Cone south of Kane Canyon. Basaltic lava flowed northwest to Kane Canyon and then north down the alluvial slope. Later material spread to the south and southeast of the cone. The cone rises 200 feet above the surrounding flow surface and is partially breached on the northern side. It is composed of basaltic bombs and scoriaceous fragments, with a circular strike and outward dip away from the crater in the center.

The "Malpais" basalt overlies and surrounds outcrops of the post-Red Mountain andesite gravels and rests upon the basement complex and alluvium. It is believed to be closely related in time to the Black Mountain basalt, despite its conformity to the alluvial slope, for near the western edge of the flow east of Kane Springs, the basalt is overlain

FIG. 7. Photograph showing section of the post-Red Mountain andesite gravels in the Lava Bed Mountains. The section is capped by Black Mountain basalt flows and is cut by strike faulting. The most complete section is to the left of the picture. The level shoulder of the ridge in the right distance consists of gravels deposited since the extrusion of the basalt capping the main ridge.

by rhyolite tuff and gravels, which south and west of Kane Springs are basal members in the post-Black Mountain basalt fanglomerates.

Capping Fry Peak, at the southern border of the Fry Mountains, basalt flows rest upon the granitic rocks and extend as a narrow tongue north from the summit. Several isolated areas of tilted basalt rest on

the granite northeast of the peak. These may have, with the lava flow of Fry Peak, at one time formed a continuous sheet.

Basalt flows cap the main ridge crest of the Lava Bed Mountains and extend down the back slope on the northern side of the mountains. The flows rest upon the post-Red Mountain andesite gravels and are overlapped on the southeast by fanglomerates derived from the basalt

FIG. 8. Edge of the "Malpais" basalt flow in Kane Springs Canyon, Newberry Mountains. The lava overlies the alluvium at this locality.

flows. Basalt dikes, apparently feeders for the flows, are emplaced in strike faults which cut the underlying gravels. The unit ranges from 100 to 300 feet in thickness, consisting of many thin flows.

Extensive areas of basalt flows rest with angular and erosional unconformity upon the underlying Tertiary sediments and volcanics of the Bristol Mountains. Resting on the basalts, and in some places interbedded with them, sanidine rhyolite flows occur. The basalt flows are commonly tilted, although a large, nearly horizontal flow surface in the northern Bristol Mountains has not been disturbed. The thickness of the unit in these mountains is variable, with a possible maximum of 400 feet.

Petrology: The rocks of this group are predominantly olivine basalts; locally augite basalts occur. They are generally dark-colored, usually black, sometimes brown or gray. They are dense, compact, and fine-grained, showing vesicularity near the tops and bottoms of the separate flows. The vesicles frequently show an elongation in the direction of flow and are commonly coated with calcium carbonate and zeolites. The rock consists of olivine (0-30%) and augite (0-8%) phenocrysts enclosed in a pilotaxitic, locally trachytic, groundmass composed of plagioclase microlites (30%), with interstitial olivine, augite, finely divided magnetite, and in some instances, basic glass. The olivine is partially altered to bowlingite, which developed around the borders and along cracks.

Volcanic Flows and Cones of Mt. Pisgah and Sunshine Peak. Apparently the youngest volcanic activity in the area is represented by the lava flows and cones of Mt. Pisgah and Sunshine Peak.

A lava flow, erupted from a central vent situated near the site of the Mt. Pisgah Cone, is located between Troy and Lavic Basins. All the lava was not erupted at one time. A definite age sequence indicates that volcanic activity was intermittent, as later flow material rests on

or surrounds the earlier basalt. Flows extend west into Troy Basin and east into Lavic Basin on to Lavic Dry Lake. The playa sediments have lapped around the flow, but the initial flow margins are not concealed. Elsewhere the lava rests upon alluvium, or is partially buried beneath thin alluvial covers. As a last event in the volcanic sequence, pyroclastic activity became marked, and from the central vent bombs and scoriaceous fragments were ejected, to accumulate as the Mount Pisgah Crater which rests upon the flows at the divide between the two basins.

The flow tops are characteristically blocky and often consist of irregular cakes and crusts of lava, which have been jostled by movement of the underlying molten material.

The basalt flows located on the northern flank of Sunshine Peak, extend as an irregular inclined apron northward to the floor of Lavic Dry Lake. Along the margins of the lake, playa sediments have partly buried the edges of the flows. Two general age groups of lava are distinguishable. The first appears to have erupted along a fissure, north of the present Sunshine Cone; and the flow was in general north and east down upon Lavic Lake, and around the hills to the northwest. Two cones were built, only remnants of which remain. The second group was erupted near the present Sunshine Cone and flowed down to the lake surface on the south and east. A branch spread north and then broke across to the east over the pre-existing lava. A tongue from this branch crossed the older broken cone, coating the surface of the crater and lapping up and around the second older cone, filling its

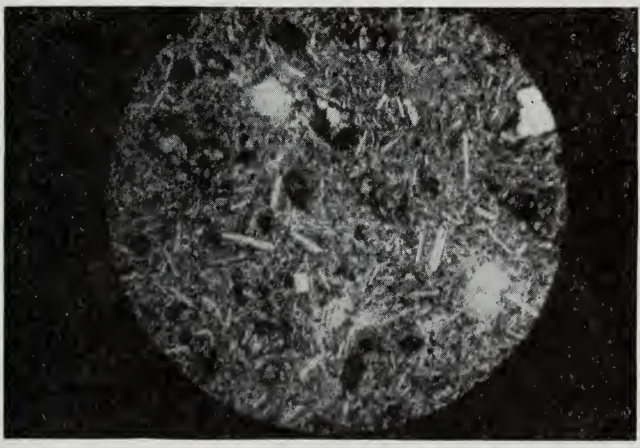

FIG. 9. Photomicrograph of olivine basalt from the Black Mountain basalt series, which caps the first ridge south of Basalt Peak.

crater and breaking over to flow a short distance down the canyon to the northwest.

Sunshine Cone is a perfect, unbreached circular cone with a central crater nearly 300 feet across and 50 feet deep. In the center of the crater a small playa about 80 feet in diameter occurs. The cone is composed of angular volcanic fragments, well bedded, which dip 24° outward. Gullies have been cut, especially on the southwest side, which

are 2 to 15 feet in depth; none of these have existed long enough to work headward and penetrate into the crater.

Petrology: The rocks are dense black or gray olivine and augite basalts. They are often vesicular and scoriaceous with dull whitish coatings on the interior vesicles. This coating weathers to a red-brown powder. The rock consists of olivine and plagioclase phenocrysts with rare augite, enclosed in a pilotaxitic, occasionally trachytic, groundmass composed of plagioclase microlites set in a mesh, the interstices of which are filled with augite grains, magnetite, and basic glass.

Correlation and Age. A comparatively recent origin is indicated for the two lava flows in the region about Sunshine Peak and Mt. Pisgah: (1) Both overlie the alluvium, one on the flank, the other in the trough of the present basins. (2) Both conform to the present topography. (3) Both are only slightly overlapped by playa sediments of Lavic Lake. (4) The surfaces of both are fresh, slightly weathered, and lack vegetation. (5) Both cones are only slightly dissected. (6) The thin flows of both are persistent on the valley floor. (7) Both are unaffected by fault movements.

By comparison, an older age is indicated for the flows of the Black Mountain basalt. (1) They show discordance with present topography. (2) They rest on older rocks than alluvium. (3) The rocks are commonly tilted, sometimes at high angles. (4) A fanglomerate series is derived from them. (5) No cones are associated with them. (6) Considerable dissection of the basalt flows and underlying material has occurred since their extrusion.

The "Malpais" flow possesses features of both groups and is believed to be intermediate in age, although perhaps more closely related to the time of the Black Mountain basalt; for it is overlain by gravels and rhyolite tuff, and thus is separated from the flows of Mt. Pisgah and Sunshine Peak.

Basalt flows around Fry Peak and to the south of latitude 34° 30′ are considered to be early Quaternary [31]; these are adjacent to, and one outcrop is coextensive with, areas mapped as Black Mountain basalt.

Considering the mode of occurrence and overlooking the minor differences in rock types, the practical equivalence of the flow material in the Newberry and Randsburg areas is indicated, and the formational grouping into the Black Mountain basalt can be considered to be correct. In the Randsburg region the Black Mountain basalts have been placed between the middle Pliocene and the Pleistocene.[32] Within the Newberry and Ord Mountains a possible age of late Pliocene is indicated for a portion of the basalt, with sporadic extrusion in the Pleistocene continuing up to relatively recent time.

Post-Black Mountain Basalt Fanglomerates

A series of fanglomerates composed largely of basalt boulders rests unconformably upon the Rosamond, the basement complex, and the Malpais flow. Locally a basalt rhyolite bed is found. The series was not recognized outside of the Newberry and Lava Bed Mountains.

Fanglomerates which extend west from Kane Springs and along the northern side of Camp Rock trough are of this series, and conformably overlie a basal marker bed. Farther south and west of Kane Springs the series rests unconformably upon the Rosamond with angu-

[31] Vaughan, F. E., *op. cit.*, p. 384.
[32] Hulin, C. D., *op. cit.*, pp. 58-60.

lar and erosional discordance. In the western extension of this belt, it rests upon Black Mountain basalt at one locality, elsewhere overlying the granite, which occurs as small exposures.

On the western side of Kane Mountain, scattered patches of gravels may be the equivalent of the fanglomerates exposed on the northern side of Kane Canyon.

East of Kane Springs an extension of the series overlies the most westerly edge of the "Malpais" flow. The marker bed and underlying gravels are broken by faulting.

On the southwestern side of the Lava Bed Mountains, the fanglomerates cover the contact between the gravel series and the Red Mountain andesite. They are derived from the Black Mountain basalt flows capping the ridge and from the post-Red Mountain andesite gravels comprising the intermediate portions of the ridge.

The sediments of this unit are typical fanglomerates, commonly poorly bedded, massive, and unsorted. They are composed of angular to rounded boulders of basalt with admixtures of other material.

A rhyolite marker bed is found in Kane Canyon in the vicinity of Kane Springs. It rests upon the "Malpais" flow, though separated from it by 20 feet of gravels, south of Kane Springs. West of Kane Springs it occurs as a well defined bed, overlying the Tertiary volcanics with angular and erosional unconformity and overlain by several hundred feet of fanglomerates. The bed is variable in thickness. Immediately west of Kane Springs it is about 150 feet thick; to the west and southwest it thins rapidly and disappears. It is not present along the northern contact of the fanglomerates with the underlying Rosamond and must thin rapidly in that direction.

Petrology: The rhyolite is commonly pale pink in color, weathering to a reddish brown. It is distinctly porphyritic, with small, clear phenocrysts of sanidine (12%) enclosed in a glassy groundmass. Basaltic hornblende and occasional titanite, zircon, and magnetite grains are the other crystalline constituents. The groundmass (80%) consists of light-colored acidic glass with irregularly shaded blebs which suggest incipient crystallization centers. In some instances the groundmass has a tuff-like appearance, while in other rocks it is dense, compact, and dark in color. Rarely, angular fragments of acidic lava are included within the rock mass. These consist of sparse sanidine and brown hornblende phenocrysts enclosed in a glassy groundmass in which tabular feldspar microlites occur.

The group of fanglomerates rests upon the Black Mountain basalt, in two instances with conformity. In several localities the marker bed overlies the truncated, upturned Tertiary volcanics. Inasmuch as the detritus is largely from the Black Mountain basalt, the series is post-Black Mountain basalt, and is thus of Pleistocene (?) age. The relation to younger formations is unknown, and while the unit is older than the older alluvium, its relationship to the Daggett lake beds is not determinable.

In the Bristol Mountains a lithologically similar rhyolite is interbedded with and rests upon Black Mountain basalt; however, the two may not be correlative.

Lake Beds Near Daggett

A series of fine clays, sands, tuffaceous sandstones, and limestones occur [33] overlying the Rosamond and overlain by older alluvium.

[33] Campbell, M. R., Reconnaissance of the borax deposits of Death Valley and Mojave Desert. USGS, B 200: 12 (1902).

Lake beds extend as a narrow belt along the front of Daggett Ridge in the western portion of the Newberry Mountains south of Daggett. They are also found on the southern side of the ridge in Stoddard Valley.

East of the Daggett-Stoddard Well road on the northern front of the ridge the lower lake beds rest with apparent conformity upon the Rosamond gravels; farther to the east, the basal agglomerates of the Rosamond strike directly into the lower lake beds with evident unconformity. To the east of the Daggett-Ord Mountain road, the lake beds rest upon and are in fault contact with the granite. Overlying the lake beds the gravels of the older alluvium extend continuously along the front, dipping north at about five degrees into the lower Mojave Valley.

South of Daggett Ridge, fine sands and clays extend continuously, striking parallel to the ridge and dipping south at low angles toward Stoddard Valley. These beds are not traceable into the beds on the northern side, but seem to be equivalent to them, at least in part, although the exact relationships are in doubt.

The lake beds consist of fine clays, sands, tuffaceous sands, and limestones. The bedding is thin, continuous, and even; but lateral variation in the thickness of the major units is well defined. A possible maximum thickness of 640 feet is shown.

No direct evidence of the age is available, but the beds are younger than the Rosamond and older than the older alluvium. A fragment, possibly of Red Mountain andesite, was found in the basal tuff, indicating a late Tertiary or Quaternary age.

A possible correlation with the Manix lake beds [34] may be determined by further work, but at the present time no such correlation can be made.

Alluvial Deposits

All unconsolidated deposits of Quaternary age are designated as alluvium. This was not mapped unless it covered a considerable area, and was thick enough to mask the underlying bed rock. There are two divisions within the unit: (1) an older alluvium; and (2) a more recent alluvial filling. The two are commonly separated in mapping; in many instances, however, it is impossible to distinguish between them.

Older Alluvium. Areas mapped as older alluvium occur in the northern Newberry Mountains, in Stoddard Valley, and in other scattered localities.

Extending from Newberry Peak westward along the mountain front, scattered remnants of an extensive alluvial fan occur. These remnants, while nearly conformable with the present alluvial slope, are deeply dissected. They rest upon an even surface cut in the granite, or with conformity upon the Daggett lake beds. Uplift of Daggett Ridge has caused the rapid erosion of the lake beds, and the gravels are left capping the northern slopes.

High gravel ridges extending west from Ord and South Ord Mountain into Stoddard Valley may represent the same depositional

[34] Buwalda, J. P., Pleistocene beds at Manix in the eastern Mojave Desert region: Cal Univ, Dp G, B 7: 443-464 (1914).

time as the older alluvium. These beds overlie the Daggett lake beds unconformably.

Older alluvium occurs in Box Canyon, unconformably overlying the sedimentary beds of the Rosamond. These beds are younger than the post-Red Mountain andesite gravels and are involved in the faulting along the granite-Rosamond contact.

Recent Alluvium. Material mapped under this designation includes alluvial fan and cone detritus, playa lake beds, talus accumulations, rock mantles, and sand dunes. The material is either in the process of formation at the present, or is of recent origin.

Recent alluvial detritus is widely distributed within the area, and occurs surrounding all the mountainous areas as alluvial fans and cones, and in the valleys which cut into the mountain masses. Playa lake beds occupy the lower depressions of the basins. Talus accumulations are common near the base of steep cliffs and scarps. Sand dunes occur in Lower Mojave Valley in two areas: (1) between Minneola and Newberry north of the railroad; and (2) along the base of, and extending up on the western flank of the Cady Mountains.

Wherever found, the alluvium, old and young, possesses the same characteristics. It is composed of angular to sub-angular fragmental material which is poorly sorted and rudely stratified. There is an increase in the degree of fineness and the perfection of the sorting away from the mountain fronts, although sporadic boulders are included within the alluvium miles distant from the source. The playa lake beds are fine brown silt and clay material with rare sandy lenses and occasional larger fragments resting on the surface or embedded in the clay.

STRUCTURAL GEOLOGY

At least three, and possibly more, systems of faulting are evident in this area. Time relations cannot be distinguished exactly; in some instances movement along older systems seems to have been contemporaneous with or even later than movements along earlier systems. The faults are described in the supposed age sequence.

The north-trending faults are few in number. The best examples are the faults which outline Muffin Hill on the west side of Lucerne Valley; these step the highland down to the basin level. The relation of these faults to later rift lines is not determinable.

These faults affect all units from the Archean up to and including the lake beds near Daggett. The northern front of Daggett Ridge is paralleled by a fault of this type which is generally normal, although near the eastern end of the ridge it is a reverse fault. Fragmentary members of this system are found in various localities, generally broken by northwest trending rifts. The time of inauguration of this system is not known; but there is no evidence that it is pre-Tertiary in age.

The most prevalent system, the latest, and the one upon which there has been the most recent movement, trends northwest. These faults cut all formations including the alluvium. They are important in the control of the physiography, and outline the present mountain ranges and basins. Whenever the fault plane could be examined, it was found to be of the normal basin-range type, except in one instance near the head of Box Canyon, where a high-angle reverse fault marks

the granite-Rosamond contact. The reverse dip extends for less than a mile, and passes in both directions along the strike into normality.

In many instances, the position of these rifts can only be inferred from a consideration of the physiographic evidence. In such cases, due to the uncertainty of position, many of them are not located on the map.

A series of northeast-trending faults is sparingly represented, the members of which in most cases seem to be complimentary to the northwest-trending faults.

The major structure of the region is relatively simple. Two northwest-trending troughs, which pitch to the southeast and flatten to the north, are controlled by major fault zones. Displacements on these faults are greatest toward their southern extensions. Subsidiary blocks have moved vertically with respect to each other.

The most westerly trough is the Lucerne-Dale [35] which lies between Lucerne Valley and Dale Basin. The southern termination is along the east-west Pinto fault [36] which lies between the Dale Desert and the highland of the Little San Bernardino and Pinto Ranges. On the west the trough abuts against the rifts along the northern border of the San Bernardino Mountains. The eastern border of the trough is along the Newberry fault zone which borders the Newberry and Bullion Mountains.

Dale Dry Lake, in the southeastern corner of the Lucerne-Dale trough, has an elevation of 1181 feet; in the Lucerne Valley the lowest elevation is 2,650 feet. From these two localities, elevations increase toward the Ord, Newberry, and Bullion Mountains. The Lucerne-Dale trough represents a rectangular block of the earth's crust, averaging 60 by 28 miles, which has been displaced along normal faults. Subsidiary blocks within the trough have adjusted themselves.

The Barstow-Bristol trough [37] parallels the Lucerne-Dale trough on the northeast. It is the larger of the two, extending from an unknown point north of Barstow, southwest to and beyond Bristol Dry Lake, for a distance of about 110 miles. The Barstow-Bristol trough is bounded on the northwest by the Bristol and Cady Mountains, which parallel the Cadiz fault [38] zone; on the southwest the Newberry and Bullion Mountains form the boundary along the Newberry fault zone. Between these mountain areas, low standing blocks and basins are found along the entire length of the Barstow-Bristol trough, bounded on both north and south by mountain blocks uplifted and outlined by major fault zones. Within the trough, elevations are lowest toward the southern extension.

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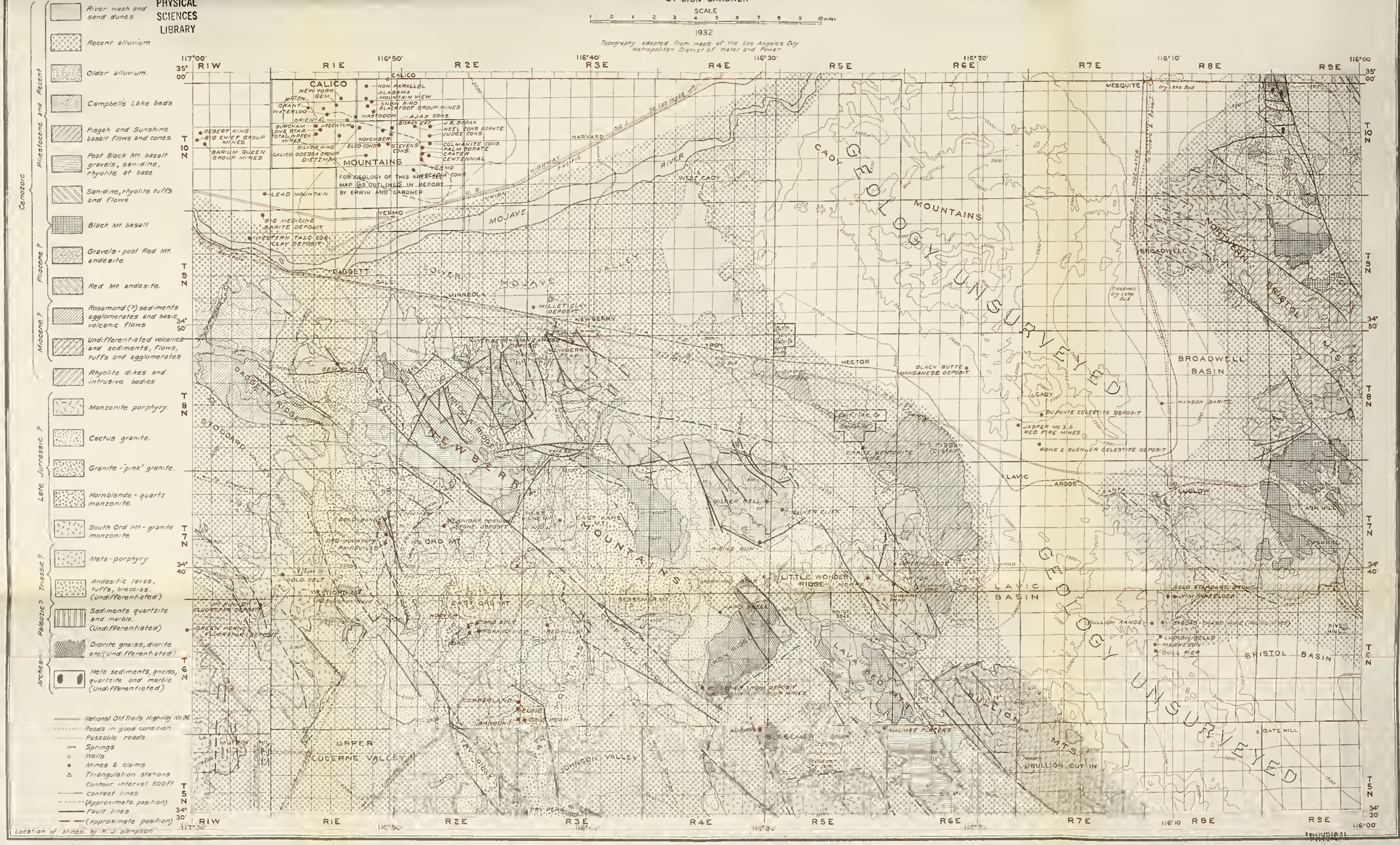
[35] Thompson, D. G., *op. cit.*, p. 612.
[36] Hill, R. T., *op. cit.*, pp. 146-147.
[37] Thompson, D. G., *op. cit.*, p. 120.
[38] Hill, R. T., *op. cit.*, pp. 155-158.

GEOLOGIC MAP OF NEWBERRY, ORD, AND NORTHERN PART OF BRISTOL MOUNTAINS, SOUTHERN CALIFORNIA

BY DION GARDNER



Accompanying Report of Dion Gardner and R. J. Sampson, California Journal of Mines and Geology, July 1940

NOTES ON THE GEOLOGY OF A PORTION OF THE CALICO MOUNTAINS, SAN BERNARDINO COUNTY, CALIFORNIA

By Homer D. Erwin * and Dion L. Gardner **

OUTLINE OF REPORT

ABSTRACT

The Calico Mining district, famous for its production of silver during the years 1883-1895, is located in the Calico Mountains. The rocks which compose these mountains are essentially middle Tertiary volcanics and lake-bed deposits (which may possibly be correlated with the Rosamond formation), a late Tertiary lava capping, and Quaternary gravels. Normal faulting outlines the mountains. A most interesting structural feature is a thrust fault of unknown displacement—readily traceable for about 5 miles along the lower front of the range. Veins, which occur in the central volcanic mass and lake beds, trend generally northwest. The dips are vertical to steeply southwest. Ore in the district consists of chlorides and chloro-bromides of silver in a gangue of barite and jaspery silica with coatings of cerargyrite and embolite. Galena and sphalerite also occur with minor amounts of chalcopyrite. Iron oxide, chrysocolla, and pyrolusite are essential supergene minerals. Part of the chlorides and chloro-bromides may be supergene, although the bulk of the ore is thought to have been deposited by ascending thermal (hypogene) waters near the surface.

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INTRODUCTION

Location and Accessibility

The Calico Mountains are situated north of the town of Yermo on Highway 91 in San Bernardino County, California. The range is readily accessible by auto over several roads maintained by the county. These parallel the mountain front and penetrate into Odessa, Mule, and Sunrise Canyons, the town of Calico, and mines to the west. The average elevation at the base of the range is about 2,000 ft., and Calico Peak, the highest point in the mountains, is over 5,000 ft. in elevation.

Purpose of the Work and Acknowledgments

Work was initiated to furnish a geologic reconnaissance of a region formerly important for mining. A detailed investigation was not attempted, for limited time and the lack of a good base map made this impossible. Despite the economic importance of the region—the Calico Mining district has produced over $20,000,000—there is no adequate topographic map of the Calico Mountains; so Public Land Survey Maps, supplemented by Mineral Land Survey Maps, were used. It is regrettable that no aerial mozaic was available, for the distinctive color differences in rock units and the excellent exposures make the area especially worthy of study.

Thanks are extended to Marsman and Company of California who aided the project; to Dr. Olaf P. Jenkins and Mr. W. B. Tucker of the California State Division of Mines for valuable assistance; to Mr. Granville Moore and Mr. C. D. Hill of the Burcham mine; to Mr. Jack Moore of the Union mine, and Mr. Jack Coke of Calico, who aided the project in various ways; and to Mr. Thomas Williams and Mr. McCormick of Yermo, who assisted in finding some of the necessary section corners. A geologic map of a portion of the Burcham mining property, prepared by Dr. C. D. Hulin, was very helpful; thanks are extended to the owners of the Burcham mine for permission to incorporate a few general features from this map.

The present field map and report are based on 15 days of field and office work by Mr. Erwin, and 10 days by Mr. Gardner.

Previous Investigations and Reports

To date little original work has been done in the Calico Mountain region in the way of accurate geologic mapping, apparently because no good base map is available. A few local and private investigations of the various mineral areas have been made. Papers of special interest are listed below:

Mining and Scientific Press

Calico district: M Sc Press 50:173, 180 (1885)

Lindgren, Waldemar

The silver mines of Calico, California. Am I M Eng, Tr 15:717-734 (1887)

Storms, W. H.

The mines of the Calico district (San Bernardino County, California). Eng M J 49:382-383 (1890)

The Calico mining district. Cal St M Bur, St Mineralogist's Rp 11:337-349 (1892)

Palmer, L. A.

The Calico district, California. M Sc Press 116:755-758 (1918)

Foshag, W. F.

Calico Hills (San Bernardino County, California). Am Mineralogist 7:208-209 (1922)

Weeks, F. B.

Possibilities of the Calico district (San Bernardino, California). Eng M J 119:757-763 (1925)

UNDIFFERENTIATED TERTIARY VOLCANICS

Tuff Series

These rocks comprise the main portion of a prominent volcanic series in the southern and western Calico Mountains. They are massive, heavy to medium-bedded tuffs showing red, brown, and gray colors, and forming a step-like structure in the higher fronts of the range. Their strike ranges from northwest to north-northwest, their dip from 10° to 40° southwest.

A typical section through the series in the western Calico Mountains is as follows:

(1) Light yellow-gray mineral-fragment, medium to fine-bedded tuff of probable rhyolitic composition. This rock and material closely resembling it form the bulk of the tuff series. The type rock is composed of a yellow to gray-colored, fine matrix cementing material and small rock fragments. Distinct rounding of fragments suggests a water-laid origin.

(2) Red-brown fragmental tuff of probable andesitic composition. This rock is next in abundance to the lighter-colored tuffs of the series. It is generally of pronounced clastic character and is composed of rock fragments of pre-existent tuffs and lavas cemented by a matrix of fine reddish, clastic material. A portion of this series is also composed of basic lava flows.

(3) Purplish-red, medium-fine, water-laid sandstone, tuff, and associated lava. The latter two are probably andesitic in composition.

(4) Yellow-green, medium-coarse water-laid tuff, similar in composition and texture to (1).

(5) Light-pink to brown, medium-coarse tuff and agglomerate, both of probable andesitic composition.

(6) Dark-gray to light-colored fragmental tuff of probable rhyolitic to near-andesitic composition. This member varies considerably in appearance, but generally is made up of coarse clastic rock containing various lava and tuff fragments up to a foot or more in diameter imbedded in a fine to medium-fine tuffaceous matrix. A variable texture results in a pronounced cavernous appearance.

Yellow Tuff Breccia

Interbedded with the tuffaceous series on the southwest front of the Calico Mountains is a particularly interesting body of rock, worthy of special note. Along a portion of its southern contact with the lake-bed series, the megascopic 'porphyritic' and massive appearance of the rock suggested, at first inspection, an eruptive invading the sediments. However, as more of the contact was mapped, it became apparent that the rock was probably of noneruptive origin. Underground workings show that the texture is profoundly clastic. The mass consists of a medium to coarse breccia of tuff fragments in a matrix of finer material. The entire body is believed to be of rhyolitic or near rhyolitic composition, and has a yellowish to cream-gray field appearance. From a distance, rude heavy bedding is evident which further suggests a sedimentary origin.

Granite Breccia

Of special interest in the tuff series, also, is a unique granite breccia. It lies in the NW$\frac{1}{4}$ Sec. 16, T. 10 N., R. 1 E., S. B., and forms an elongated body approximately one-half mile in length that trends N. 50° W. At first, this mass of rock appears to intrude the surrounding volcanic tuff. Though it is faulted along at least a part of the

contacts of the two longer dimensions, its intrusive nature is suggested by penetrating tongues and embayed contacts along the remainder of the contacts. There is no sign of alteration of invaded rocks. The outcrop has a massive appearance and shows no sign of stratification.

The mass is a pronounced breccia, the fragments of which possess a granitic texture. They are intimately included in a fine-grained, dense, red aphanitic igneous matrix of shallow intrusive origin. In a few instances resorption of granitic fragments was observed.

The included granitic fragments caught in the throat breccia of a central volcanic vent, consist of three types supposedly derived from the bedrock complex. The most striking, often found in masses five feet in diameter, is a coarse, equigranular granitic rock consisting of feldspar, quartz, and abundant biotite. The second type forms smaller blocks and is finer grained but similar to the first in texture and mineral constitutents. The third and most abundant rock fragment, usually less than four inches in diameter, is a fine- to medium-grained granitic type consisting of quartz and biotite with feldspar. In addition to the granitic fragments, a dark-green distinctly porphyritic rock also occurs as fragmentary material in the breccia.

In addition to the above variegated assemblage the tuff series includes a pure limestone member at one locality to the west.

Although the original thickness of the tuff series is not known, it was presumably between 1,500 ft. and 2,000 ft. Some of the material has been removed by erosion.

The members of this series are lake and continental (fluviatile) deposits resulting from a violent and prolonged period of volcanic explosive activity near large inland bodies of water. These, as well as the lava-agglomerate series described below, are pre-lake-bed sediments which are tentatively classified as Rosamond (?) or upper Miocene. The volcanics are possibly lower Miocene in age.

Lava Agglomerate Series

The lava agglomerate series of undifferentiated Tertiary volcanic rocks forms a large part of the total assemblage, and lies largely in the south-central portion of the Calico Mountains with the later tuff and sedimentary series areally surrounding it in all the areas observed. This series has been referred to variously as 'liparite' or 'rhyolite' and forms the dominant core of older rocks in the vicinity of the richest mines of past years.

This series consists of red-brown to chocolate-brown lava flows and agglomeratic beds with included areas of greenish rock which have resulted from hydrothermal alteration of the lavas. The members dip at moderate angles in various directions of the compass, as a result of faulting in the originally moderately dipping formations.

A typical and abundant rock of the series is a dominantly red and red-brown, with grayish phases, medium-porphyritic andesite. Phenocrysts of feldspar (chiefly plagioclase), round, partially resorbed quartz, and sparse biotite can be seen in the hand specimen. The groundmass is dense, fine-grained aphanitic, and exhibits no particular megascopic structure. Alteration phases are typically propylitic with prominent development of green-colored rocks showing distinct

relic porphyritic appearance. This alteration is due principally to mineral decomposition by the vein and early metalizing solutions which rose along pre-existent fractures in the rocks, but antedated most of the ore mineralization. Flow banding is occasionally prominent in the unaltered rock areas, but flow lines are sparsely developed. In cross-joints in the lavas, calcite, jasper, and barite mineralization carries some metallic minerals in narrow veins, but these are of little economic value.

Another rock of the red series is light purple in color and distinctly vesicular. It exhibits a sparsely, medium-fine porphyritic texture with phenocrysts of plagioclase, biotite, and quartz in a groundmass of aphanitic material containing fine feldspar microlites and glass. This rock is probably a dacite. One flow is from 50 to 100 ft. thick, and is immediately overlain by the tuff-breccia on the southwest slope of Wall Street Canyon.

Besides the predominant lava flows, the series consists in its upper portion of 500 ft., more or less, of largely sedimentary beds—fine to medium-grained reddish sandstones, dark-red to brown fragmental tuffs, coarse red agglomeratic and conglomeratic members and reworked detrital gravels which were originally derived from the higher portions of the earlier lava series. These gravels are the youngest of the lava series and lie conformably under the lake-bed series. In Wall Street Canyon, immediately west of Calico, the following rock types are found in the upper lava agglomerate series between the lower tuff member of the lake beds to the south, and the green alterations of lava to the north.

(1) 160 ft. of yellowish-gray, well indurated, fine-textured tuff containing scattered fragments of rock up to several inches in diameter.

(2) 50 ft. of dark-gray, coarse fragmental tuff.

(3) 75 ft. of light greenish-yellow medium-coarse fragmental tuff.

(4) 70 ft. of chocolate-brown medium to medium-heavy-bedded fragmental tuff and agglomerates. These are probably andesitic in composition and include the red gravels above mentioned as derived from the higher masses of pre-existent lava and agglomerates.

The total thickness of the lava series is between 1,500 and 2,000 ft. which, no doubt, is something less than the original accumulation.

The lava series was thought to have been deposited more or less contemporaneously with the tuff series, but in some localities, as on the southwest wall of Wall Street Canyon, the tuff (breccia) seems to overlie the red lavas. In the Newberry and Ord Mountains to the south of Calico Mountains Gardner * found a series of undifferentiated Tertiary tuff, lava, and agglomerate which he regarded as lower Miocene. The Calico Mountains assemblage of lava and tuff seems to correlate with this series.

POST-VOLCANIC SEDIMENTARY SERIES

Lying more or less conformably on top of the volcanic mass of rock are sedimentary lake beds and associated tuffs and flows, which form a most important unit of the stratigraphic column. These beds extend continuously along the lower front of the range to the west, south, and east in the areas mapped.

* *See* accompanying report by D. L. Gardner, Geology of the Newberry and Ord Mountains, San Bernardino County, California.

In appearance the sedimentary beds are light gray to green and brown in color, fine to medium heavy-bedded, water-laid arkosic sandstones, thin-parted argillaceous rocks and tuffs. Thin to medium-bedded limy shales and calcareous sandstones are not uncommon, being more prominent near the base of the series. The attitudes of these rocks are quite variable due to crumpling, folding and faulting. Folding in the beds seems sharpest near the valley fill in the vicinity of the thrust, becoming more moderate (25° to 40° to the south) northward. Synclinal and anticlinal structures were locally observed.

Near the base, and apparently interbedded with the sedimentary series, are two igneous rocks. One is dark-green in color on fresh fracture and yellow-green on altered surfaces. This rock is distinctly porphyritic, containing plagioclase phenocrysts, dark-green hornblende, and scattered biotite set in a dense aphanitic matrix—probably a hornblende andesite.

The second igneous rock is reddish-purple in color and shows definite phenocrysts of plagioclase and needles of brown hornblende in a fine-grained pink aphanitic groundmass. Minor flow banding is present. East of Mule Canyon, this rock occurs in association with the green porphyry. An intrusive relation is believed to exist between the two, the pink porphyry being the invading rock. This is further substantiated by alteration due to pneumatolysis along contacts, which gives pink, orange, and yellow alteration patches in the rocks, which are evident when the range is observed from the valley.

In close association with the sediments of the lower volcanic part of the sedimentary series are several members of hard, banded, gray, green, blue, and brown cherts. These occupy the lower frontal slopes and ridges of the hills to the west and northwest in the regions observed. They possibly were derived from the action of siliceous volcanic springs that fed inland bodies of water for a long period of time. Stratigraphically, they appear low in the lake-bed series. However, only fault contacts were observed, and determination of their true relationship to the rest of the series requires a more detailed study.

The total thickness of the lake beds is not known, for they dip or are faulted under the valley fill, and where they are exposed, are often repeated, at least in part. The thickness probably ranges upward from a minimum of 1,000 ft.

At the top of the sedimentary series, immediately below the overlying volcanics, a yellow-gray, water-laid, medium- to fine-bedded, soft tuff occurs. This varies in thickness from 500 ft. towards the west to 300 ft. to the south. The thickness to the southeast and east is not known, but is believed to be greater than elsewhere.

The various beds appear to have been deposited in a large inland body of water which received a continuous supply of tuffaceous and terrigenous material.

The sedimentary series is younger than the tuff-lava agglomerate series, and may be roughly comparable to the Rosamond series, which it lithologically resembles in many respects. Pending further study and possible discovery of fossil remains in the beds, no further discussion on this point can be made.

RED MOUNTAIN ANDESITE (?)

This rock occurs as a distinct capping above all pre-existent volcanic and sedimentary formations, in the southeastern portion of the Calico Mountains in the area surveyed.

It is a dark-brown rock which lies more or less horizontally or at low dips on the eroded surface of sediments and associated lavas. A fresh surface of this rock reveals a dark-brown to reddish-brown distinctly porphyritic texture of apparently andesitic composition. Feldspar phenocrysts up to a quarter of an inch in length occur in a dense, reddish, aphanitic groundmass.

Although this rock is largely a capping, at one locality in the extreme southeast part of the mountains, steeply dipping contacts suggest an intrusive mass. It is possible that this locality may represent the site of the volcanic throat and source of part of the cap rock. Associated agglomerate masses tend to confirm this interpretation. Elsewhere the flows lie on top of the eroded surface of the volcanic and sedimentary series, and upon the gravels derived from erosion of these formations.

The total exposed thickness of this unit is between 500 ft. and 700 ft., though this is, no doubt, only a part of the original accumulation.

In age, this lava is post-sedimentary, and on the basis of correlation with other areas is tentatively classified as lower Pliocene.*

QUATERNARY GRAVELS

Following the uplift of the range, the various units were attacked by the forces of desert erosion with consequent development of gravels in canyons and alluvial fan deposits extending out from all mountain fronts. Considering the amount of dissection, there is not a great deal of detrital material visible, indicating fairly recent movement along the frontal fault zones.

In common with adjoining mountain ranges, high dissected gravels with banks ranging from 10 ft. to 30 ft. in height are found in the canyons. These are indicative of a slightly older period of erosion and deposition.

GEOLOGIC STRUCTURE

As indicated on the diagrammatic cross section, a granitic basement complex is believed to underlie the range, buried beneath the massive red andesite flows, agglomerates, tuffs, and lake-bed series. Both volcanics and lake beds are broken by faults of two distinct types—normal frontal faults, and a thrust—which trend in a general northwest direction, paralleling each other. Tear faults with a northerly trend occur in close relation to the thrust along the lower front of the range, breaking it into several units. Vein fissures and faults of lesser displacement, parallel the thrust with reverse dip, and seem to be due to relaxation adjustments in the upper thrust block. These appear to die out at shallow depth and probably do not continue below the thrust, although this is problematical, as no extensive mine development has been done below the thrust plane. It is evident that the

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* Hulin, C. D. Geology and ore deposits of the Randsburg quadrangle, California. Cal St M Bur, B 95, pp. 55-58 (1925)
Gardner, D. L., *op. cit.*

mountains were subjected to compressive stresses acting nearly horizontally. The fact that the lake beds are intensely folded, crumpled, and overturned, while the volcanic series to the north is not folded but broken, might suggest that the active forces of folding and thrusting were from the southwest. In this case, the movement would be underthrusting, with the southern block shoved under the northern. However, the fractured nature of the north block, considered in conjunction with the massive character of the andesite flows and the localization of intensely crumpled lake beds immediately along the thrust, suggests that the northern block was the active unit. Prior to thrusting, the lake bed series were folded and locally intensely crumpled and overturned. At one locality, a syncline developed along the southwestern front was broken by an axial thrust. Tear and relaxation faults developed in the thrust block, and were followed by mineralization. It appears that the mineralized fractures were stronger in the massive lava series and were dissipated in the overlying lake beds.

Long after the period of thrusting and mineralization, the present mountain range was outlined by normal and relatively recent faults. These strike more or less northwest in the areas observed, dip from vertical to 70° southwest, and drop all formations found in the mountains below the valley fill. None of the front faults are simple planes of rupture, but are separating, diverging, and rejoining splits and branches with differing amounts of displacement, evident principally because of topographic changes in the landscape. The frontal faults are paralleled, within the range, by other normal faults which further break the mountain mass into separate topographic units.

ECONOMIC GEOLOGY

Little published information on the Calico district is available, and all unpublished material is of confidential character. Consequently, it is difficult in a reconnaissance survey to form an adequate opinion regarding the ore, its origin and mode of occurrence. However, an attempt will be made to summarize pre-existing data and to present a brief but concise outline of the ore deposits.

As stated before, the general geology in the vicinity of the Calico mines is relatively simple. Basal andesite flows (?) variously termed 'rhyolite' and 'liparite' and recognized as both intrusive and extrusive by earlier workers, are overlain by 500± ft. of tuff, breccia, and sedimentary material. The lake-bed series rests on the earlier volcanic series, generally conformably, but with some local unconformity. Complex faulting, involving thrusting, and later normal faulting are in evidence along the southern front of the range. Veins are assumed to have originated as a result of continued normal tensional movements. Ore-shoots, locally rich in silver with very minor base metal and gold, are distributed in the upper portion of the veins. These were richest, so far as known, in fractures in the overriding thrust block in the vicinity of Calico. Sporadic mineralization is evident throughout the central mass of the Calico Mountains, decreasing in intensity and value farther to the northwest and southeast.

The mineral deposits of the Calico Mountains mining districts * can be classified roughly into two groups:

(1) The deposits lying in or closely associated with prominent fault fissures and wall fractures in the red lava-agglomerate, tuff, and lake bed series.

(2) Irregular and pockety shallow deposits in the tuff and lava series throughout the region.

Calico Mining Area

Silver King and Oriental Vein System. This system includes the past most important productive mines of the region. It consists of a series of prominent veins branching to the north and converging in a mass of crushed and mineralized rock towards the southeast. The veins are traceable for over two miles on the surface. The strike is northwest, and the dip vertical to 50° to the southwest (average about 70° southwest). Ores of silver chloride and chloro-bromides occur more or less regularly as fracture filling in a gangue of barite and jaspery silica. Manganese (pyrolusite) is common; finely distributed rich sulfides are sparingly present. Cerargyrite and embolite occur as thin coatings in joints and other fractures. The wall rock is a dark-brown to red lava of the lava agglomerate series. The fissures are a result of normal fault movements; the footwalls are to the north. Width varies from 2 in. to 2 ft., the average being about 8 in. Ore was exceedingly rich near the surface, but grew poorer with depth.

Intensive faulting and crushing occurs at the site of the old Red Cloud and Red Jacket mines. Here, barite and jaspery silica form a stockwork of small random veins in a zone up to 30 ft. wide. Ore is impregnated through the brecciated rock. All workings in this vein system are abandoned at present except for leasing on a small scale.

Calico-Odessa Mining Area

Bismark and Humbug Mines (*Idle*). The Bismark mine is on the divide between Bismark and Wall Street Canyons. Ore occurs in a prominent fissure of large throw, traceable for about a mile. Strike is N. 17° W., and dip 30° southwest. The ore is cerargyrite with a little chrysocolla in a gangue dominantly barite. The productive vein was 8 in. (maximum) and very rich near the surface. In depth it continues, but economic mineralization does not.

At the old Humbug mine east of the Bismark mine, there is strong mineralization in the lake-bed series, with impregnations of rich silver minerals. Ore-filled cross-joints and cracks are present in soft sediments, with secondary silver hydroxide and iron oxide. Mining was by the open-pit method.

Garfield Mining Group (*Idle*). This group lies on the divide between Garfield and Bismark Canyons, in a dense red volcanic rock.

At the old Garfield mine about 1½ miles northeast of Calico, the vein strikes west-northwest and dips about 80° west-southwest. Ore occurs in the fault fissure and forms a stockwork in the brecciated south or hanging wall. Silver ores occur in cracks in the breccia, cemented by gangue of barite and argentiferous minerals. Orebodies of cerargyrite and embolite were irregular and ranged up to 40 ft. in width. Cop-

* The description of ore deposits in the Calico and immediately adjoining areas is taken largely from Waldemar Lindgren's report, 'The silver mines of Calico, California', Am I M Eng, Tr 15: 725-734 (1887).

per is present in this area and chrysocolla is a common secondary mineral in the ore. There is some hydrothermal alteration of the wall rock.

Black-Foot Mines (Idle). This property is located about half a mile southeast of the Garfield property and lies in a decomposed and altered mass of greenish andesite. The vein strikes west-northwest, and dips around 75° to the south-southwest; its width varies from 6 in. to 10 in. and it can be traced on the surface about 400 ft. The vein fissure is prominent and ore occurs in fractured gangue. Little barite is present and silver chloride occurs in seams and streaks in the decomposed lava, tuff, and breccia. The original deposits were confined almost exclusively to the upper 30 ft. of ground.

Empire Silver-Lead Mining Property. No information is at hand regarding this property, which is shown on the mineral map of the Calico district.

Burcham-Waterloo Mining Area

Burcham Gold Mine (Formerly the Total Wreck Mine). These mine claims, located about one mile west of Calico, are at present developing low-grade gold ore in two roughly parallel veins above the frontal thrust. In addition, some ore is found along a fault zone about half a mile west of the present main workings.

The veins, termed North and South, are dissimilar in character. The South vein consists of a wide fractured zone trending N. 80° W. and dipping steeply to the southwest. It is reported to carry gold, silver, and lead, and at one time was known as the Lead vein. In oxidized ore there is a prevalence of iron-stained brecciated quartz. Small iron-oxide seams carry spotty mineralization. Development to slight depth reveals the occurrence of minor sphalerite and galena. The South vein is confined to the lake-bed series of sandstones, cherts, and shales. To the northwest it dies out rather abruptly, possibly due to structural conditions relative to the strike of the vein and strike of enclosing sediments. Roughly parallel or echelon fractures continue here but soon disappear. It seems probable that no further vein continuation exists.

The North vein, known at one time as the Gold vein, lies along the contact of the lake beds with the tuff breccia previously described. This vein trends N. 40° W. and is discontinuous in strike. It appears to die out to the east without intersecting with the South vein, and to continue in echelon structures to the north. Where observed in the main adit level, most of the gold is in narrow short shoots in the plane of the vein. Vein matter consists of iron-stained brecciated quartz with no visible sulfides or gold. It is probable that most of the gold is free in near-surface workings. The close association of the North vein with the tuff-breccia and lake-bed contact is noteworthy and suggests that vein fracture was the result of emplacement of the breccia! However, the tuffaceous nature, the bedded appearance and lack of alteration of the lake beds by the tuff breccia suggests the sedimentary origin of the tuff breccia, and localization along the contact is believed to be due to structural weakness of the contact of sediments with the massive, buttress-like tuff breccia.

It is evident that both North and South veins are localized in the thrust block, and probably do not persist below it.

Development in the west part of the Burcham property has shown the existence of a broad crushed zone showing low grade mineral values. Ore consists of mineralized, brecciated, iron-stained lake-bed material. Some quartz has been introduced. Iron oxide is present but wall rock alteration is not intense.

Waterloo Mining Property (*Idle*). This mine, located northwest of the Burcham mine, was formerly a large silver producer. Orebodies occur along the Waterloo fault zone which trends northwest, and dips approximately 40° southwest. The orebodies mined were large, irregular masses and bunches that extended over an area approximately 1,100 ft. in plan and 500 ft. in section, all above the plane of the thrust. Stope widths ranged up to 200 ft. in length, and a very large tonnage was mined from them.

No development has passed below the thrust intersection with the most productive veins, although the thrust is well exposed in the lower main cross-cut (level 17). The Waterloo fissures and ore seem to have been localized only in the upper thrust block and are not known to persist below it. Near the thrust in the lower level, the veins appear to play out, becoming lower in grade and somewhat divergent. This is substantiated by the fact that there are no stopes immediately above the lower level (long cross-cut).

Union Mining Property. This property, located north of the Waterloo, is similar in many respects to the Burcham North vein which it closely resembles in appearance and mineralization. The main vein trends N. 50° W. and dips 52° southwest, flattening 50 ft. below the main cross-cut level. The vein consists of a shear zone along the contact of the tuff-breccia and lake-bed series, ranging up to 30 ft. in width. Ore is spotty in brecciated iron-stained wall rock, with minor quartz.

Ore Genesis and Zoning

At the height of production the district was examined by several prominent geologists and mining engineers, and their views were summarized by Lindgren* and later by Storms.** The consensus at that time—that the ore deposits were formed by hot ascending thermal waters depositing the ore minerals in veins and fractured country rock—is still valid. The veins are reported to continue strongly in depth but mineralization does not. This points to a primary deposit of shallow or epithermal type.

Without detailed underground mapping, and knowledge of gold-silver ratios (lateral as well as vertical extent) in the veins, little can be said definitely regarding ore zones. However, it seems doubtful that lower ore zones exist, for, although the veins persist downward with decreasing metal content, the underlying thrust plane would seem to limit the occurrence of deeper ore. Solution damming, and telescoping of deposits above the thrust to the higher fractured wall-rock, might explain the exceedingly rich ore in the higher levels. It is pos-

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* Lindgren, Waldemar, *op. cit.*

** Storms, W. H. The Calico mining district. Cal St M Bur, St Mineralogist's Rp 11:337-349 (1892)

sible that supergene processes aided in ore concentration to a limited extent, but a primary origin is accepted, on the whole. The presence of minor chalcopyrite in the deeper workings at the Calico mines, and of galena and sphalerite in the deeper workings at the Burcham mine, indicates that these sulfides may increase with depth. Gold, so far as known, shows no definite relationship to silver in vertical distribution. It is believed, however, that certain amounts of gold are associated with all silver mineralization throughout the area observed. Gold definitely occurs with minor amounts of silver minerals in the Burcham-Waterloo area, west of Calico.

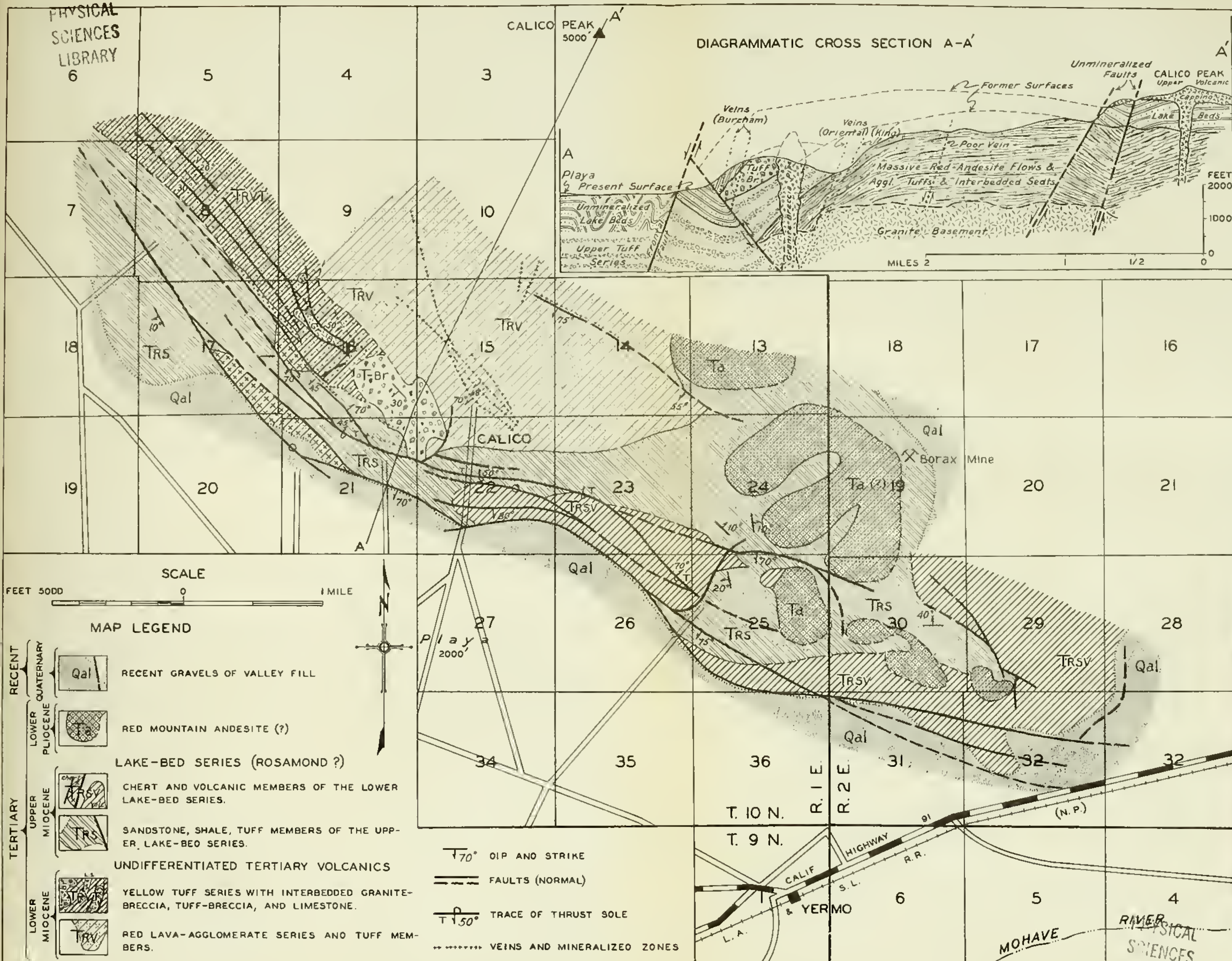
DIVISION OF MINES
WALTER W. BRADLEY, STATE MINERALOGIST
OLAF P. JENKINS, CHIEF GEOLOGIST

STATE OF CALIFORNIA
DEPARTMENT OF NATURAL RESOURCES
RICHARD SACHSE, DIRECTOR

PLATE III

RECONNAISSANCE GEOLOGY OF THE SOUTHERN CALICO MOUNTAINS. SAN BERNARDINO CO. CALIF.

BY H.D. ERWIN AND D.L. GARDNER



SPECIAL ARTICLES

Detailed technical reports on special subjects, the result of research work or extended field investigations, will continue to be issued as separate bulletins by the Bureau, as has been the custom in the past.

Shorter and less elaborate technical papers and articles by members of the staff and others are published in each number of CALIFORNIA JOURNAL OF MINES AND GEOLOGY.

These special articles cover a wide range of subjects both of historical and current interest; descriptions of new processes, or metallurgical and industrial plants, new mineral occurrences, and interesting geological formations, as well as articles intended to supply practical and timely information on the problems of the prospector and miner, such as the text of new laws and official regulations and notices affecting the mineral industry.

STUDY OF CHROME PROCESS AIDED BY MARTIN DENNIS COMPANY[1]

Two $750 scholarships have been received by the Oregon State College, Corvallis, Ore., from the Martin Dennis Company of Newark, New Jersey, for the further development of the recently discovered process of treating low-grade chromite ores. The company is interested in obtaining chromium for the leather tanning process. In addition to the scholarships, the concern will supply up to $2,000 worth of special equipment which will become the property of the college.

Joseph Schulein of Portland, a special student at the college, has developed the process and has applied for patents. Two research fellows, Glen C. Ware of the electro-chemistry department, and George Gleeson of chemical engineering, will work with Schulein. The new reduction method is applicable to the black beach sands, long known to contain gold, platinum, and chromite, and to the low-grade chrome ores, which hitherto have had no commercial value because of the expense involved in reduction and recovery.

[1] Reprinted from the Mining Journal, Phoenix, Arizona, September 15, 1940.

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ADMINISTRATIVE

WALTER W. BRADLEY, State Mineralogist

Personnel

There are no changes in personnel of the Division to be recorded for the past three months.

New Publications

CALIFORNIA JOURNAL OF MINES AND GEOLOGY, JANUARY, 1940, being Chapter 1 of State Mineralogist's Report XXXVI. This chapter contains: "Current Mining Activity in Southern California"; and special articles on "Notes on Beryl with a Qualitative Analysis for Beryllium," and "Strategic Minerals Investigation Procedure followed by the U. S. Bureau of Mines."

COMMERCIAL MINERAL NOTES (Nos. 205, 206 and 207) May, June, July, 1940, respectively. These 'Notes' contain the lists of 'mineral deposits wanted' and 'mineral deposits for sale,' issued in the form of a mimeographed sheet monthly. It is mailed free to those on the mailing list for 'California Journal of Mines and Geology.' As an evidence of the interest in mines and mineral resources now showing considerable activity, this mimeographed 'sheet' has had to be expanded to five pages in recent months.

Mail and Files

The Division of Mines maintains, in addition to its correspondence files and the library, a mine file which includes original reports on the various mines and mineral properties of all kinds in California.

During each quarterly period there are several thousand letters received and answered at the San Francisco office alone, covering almost every phase of prospecting, mining and developing mineral deposits, reduction problems, marketing of refined products and mining law. In addition to this, hundreds of oral questions are answered daily, both at the main office and the district offices, for the many inquirers who come in for personal interviews and to consult the files and library.

MINERALS AND STATISTICS

Statistics, Museum

Henry H. Symons, Statistician and Curator

Tabulations are presented herein showing the complete totals for all substances produced in California during the year 1939, grouped by substances and by counties. The complete detailed annual report on the mineral production of California for 1939 will be available later as Bulletin 119 of the State Division of Mines.

SUMMARY—1939

The total value of the mineral output of California for the year 1939 was $352,462,564, being a decrease of $27,982,392 from the total of 1938 which was $380,444,976, the decrease being due to petroleum. There were sixty-two different mineral substances, exclusive of a segregation of various stones grouped under gems; and all fifty-eight counties of the State contributed to the list.

As revealed by the following, the salient features of 1939 compared with the previous year were: The metal and industrial-materials groups showed increases in total value, while fuels, structural materials, and salines showed a decline. Of the year's mineral output gold showed the greatest increase in value, followed in turn by copper, brick and hollow building-tile, tungsten ore, quicksilver, lime, magnesite, cement, limestone, borates, talc and soapstone, silica, and salt; while those showing decreases in amount and value were petroleum, potash, miscellaneous stone, and mineral water. Returned to the commercial list after several years absence were antimony, molybdenum, titanium ores, and strontium.

Of the fuels, petroleum showed a decrease in value of $31,995,487 and a decrease in amount from 249,395,763 barrels to 224,253,110 barrels of crude. There were no marked changes in prices of crude from June, 1936, until May, 1940. Natural gas showed an increase in amount and a decrease in value from 332,358,439 M. cu. ft. worth $22,310,755 to 340,754,804 M. cu. ft. valued at $21,551,646.

Of the metals all materials under this grouping showed an increased value of output with the exception of platinum and iron ore. The gold production increased from 1,311,129 to 1,435,264 fine ounces, and in value from $45,889,515 to $50,234,240; copper from 1,613,491 lbs. worth $158,122, to 8,390,215 lbs. worth $872,582; tungsten from 46,107 units worth $786,860 to 74,110 units worth $1,153,735; quicksilver from 12,171 flasks worth $846,497 to 11,201 flasks worth $1,102,563; and silver from 2,590,804 fine ozs. worth $1,674,863 to 2,599,139 fine ozs. worth $1,764,264. The 1939 gold value was the greatest since 1856 while that of chromite, antimony, and tungsten ore was the greatest since 1919; that of molybdenum ore being greater than the total of all previous output.

Of the structural materials, lime increased in value and amount from 70,578 tons worth $683,403 to 87,288 tons worth $849,122 and its largest annual yield; cement from 10,561,037 barrels worth $15,502,574 to 10,984,033 barrels worth $15,616,219; increased values were also registered by brick and hollow building-tile, granite, marble and sandstone. Miscellaneous stone declined in value from $11,734,038 to $10,316,787; also decreased values were shown by bituminous rock and slate.

In the industrial group the total value increased from $5,027,093 to $5,622,439, with gypsum, limestone, pumice and volcanic ash, silica (quartz and glass sand), and talc and soapstone reaching all-time highs in annual production. The total value of the saline group decreased from $14,279,949 to $13,178,499, although borax, iodine, salt, and soda registered increases in total value for the year, with soda exceeding all previous annual output.

Distribution of the 1939 output of California by substances is shown on the following tabulation:

Substance	Amount	Value	Number of properties
Antimony ore	150 tons	$4,552	7
Bentonite	11,284 tons	138,854	11
Bituminous rock	16,546 tons	63,612	3
Borates	244,819 tons	5,110,807	4
Brick and hollow building tile		3,063,660	43
Cement	10,984,033 bbls.	15,616,219	10
Chromite	3,936 tons	52,673	6
Clay (pottery)	305,519 tons	611,599	57
Copper	8,390,215 lbs.	872,582	(5)
Dolomite	17,791 tons	40,391	5
Feldspar	2,076 tons	12,510	4
Gems		2,500	7
Gold	1,435,264 fine ozs.	50,234,240	(1)
Granite		145,194	15
Gypsum	219,671 tons	437,343	9
Iron ore	16,990 tons	77,788	3
Lead	1,061,294 lbs.	49,880	(5)
Lime	87,288 tons	849,122	23
Limestone	316,029 tons	838,235	
Magnesium salts	7,788,128 lbs.	382,457	3
Marble[6]		14,822	6
Mineral water	16,678,741 gals.	735,988	42
Natural gas	340,754,804 M.cu.ft.	21,551,646	(2)
Petroleum	224,253,110 bbls.	226,358,856	
Platinum	896 fine ozs.	32,135	(5)
Pumice and volcanic ash	41,109 tons	159,951	17
Quicksilver	11,201 flasks	1,102,563	78
Salt	417,956 tons	1,174,386	16
Sandstone		12,494	6
Silica (sand and quartz)	86,229 tons	349,074	6
Silver	2,599,139 fine ozs.	1,764,264	(5)
Slate	5,777 tons	28,327	3
Soapstone and talc	31,820 tons	372,078	10
Soda	200,049 tons	2,055,608	4
Stone, miscellaneous[3]	18,681,305 tons	10,316,787	355
Sulphur	4,811 tons	73,741	3
Tungsten	74,110 units	1,153,735	10
Zinc	16,390 lbs.	852	(5)
Unapportioned[4]		6,601,039	
Total value		$352,462,564	

[1] There were 1,028 lode mines and 749 placer mines, not including snipers, prospectors, and various individuals who sold small lots.

[2] There was an average of 14,617 producing wells.

[3] Includes macadam, crushed rock, ballast, rubble, rip rap, sand and gravel.

[4] Includes barite (2), bromine (2), calcium chloride (1), calcium silicate (1), carbon dioxide (3), coal (1), diatomite (3), garnets (1), iodine (2), lithia (1), magnesite (2), manganese ore (1), molybdenum (1), potash (1), paving blocks (1), pyrite (1), sillimanite group (2), strontium (1), titanium (1), tube-mill pebbles (1).

[5] Included with gold.

[6] Includes onyx and travertine.

Distribution by counties for 1939 is given in the following tabulation:

County	Value	Number of mineral products
Alameda	$2,778,587	7
Alpine	7,328	5
Amador	4,314,573	9
Butte	2,217,721	11
Calaveras	5,392,940	10
Colusa	20,149	3
Contra Costa	2,206,131	10
Del Norte	13,101	5
El Dorado	3,277,679	13
Fresno	21,275,300	16
Glenn	54,591	1
Humboldt	133,150	7
Imperial	822,271	13
Inyo	1,614,597	22
Kern	62,105,687	20
Kings	16,647,443	4
Lake	451,575	5
Lassen	46,277	4
Los Angeles	113,577,646	22
Madera	119,831	5
Marin	133,756	4
Mariposa	1,755,776	8
Mendocino	47,691	4
Merced	2,611,896	6
Modoc	23,658	8
Mono	513,357	9
Monterey	229,058	12
Napa	714,895	10
Nevada	11,468,556	9
Orange	18,850,782	14
Placer	1,710,738	11
Plumas	2,265,956	8
Riverside	3,187,902	14
Sacramento	5,875,597	10
San Benito	547,093	6
San Bernardino	14,664,598	27
San Diego	633,147	14
San Francisco	52,669	6
San Joaquin	1,104,898	7
San Luis Obispo	174,124	11
San Mateo	2,418,895	7
Santa Barbara	8,911,006	9
Santa Clara	716,346	7
Santa Cruz	3,140,742	8
Shasta	2,058,547	9
Sierra	871,212	6
Siskiyou	1,847,687	9
Solano	640,024	5
Sonoma	329,069	6
Stanislaus	1,069,730	7
Sutter	68,733	2
Tehama	82,094	5
Trinity	1,514,951	7
Tulare	452,547	8
Tuolumne	669,844	14
Ventura	20,773,214	8
Yolo	63,143	4
Yuba	3,192,056	5
Total value	$352,462,564	----------

MUSEUM

The Museum of the State Division of Mines possesses an exceptionally fine collection of rocks and minerals of both economic and academic value. It ranks among the first five of such collections in North America and contains not only specimens of most of the known minerals found in California, but much valuable and interesting material from other states and foreign countries as well.

The exhibit is daily visited by engineers, students, business men, and prospectors as well as tourists and mere sightseers. Besides its

practical use in the economic development of California's mineral resources, the collection is a most valuable educational asset to the state and to San Francisco.

Mineral specimens suitable for exhibit purposes are solicited, and their donation will be appreciated by the State Division of Mines as well as by those who utilize the facilities of the collection.

Among the specimens received recently and catalogued for the Museum are the following:

21013 NICKELIFEROUS SERPENTINE, with nodules of Hydro-Magnesite. From Sonoma County, California. In Case 234. Donor: Frank Belford. May, 1940.

21014 HEMIMORPHITE crystal group, $H_2Zn_2SiO_5$. From El Potosi Mine at El Real del Santa Eulalia, 16 miles east of Chihuahua, Mexico. In Case 133. Donor: George L. Gary. May, 1940.

21015 QUARTZ BASALT, containing large quartz crystals and small crystals of a basic feldspar in a fine groundmass. From Arroyo Grande, San Luis Obispo County, Calif. In Case 503. Donor: Sydney A. Tibbetts. June, 1940.

21016 CASSITERITE, SnO_2, tin oxide. From Gaia, Portugal; elevation, 100 feet adjoining Portuguese-American Tin Co's dredging operations. In Case 312. Donor: H. C. McKiernan. June, 1940.

21017 GOLD in DOLOMITE and QUARTZ banded with serpentine containing considerable pyrite. The dolomite is the white with cleavage faces and the dark-bluish colored material is quartz. From the property of the Carson Hill Gold Mining Corp., Melones, Calaveras County, California. In Case 304. Donor: Carson Hill Gold Mining Corp., John A. Burgess, General Manager. July, 1940.

21018 SCHEELITE, $CaWO_4$, crystal. From San Bernardino County, California. In Case 150. Donor: Carl Lofdahl. July, 1940.

21019 WOLFRAMITE in Quartz. From Minarets, Madera County, California. In Case 214. Donor: Ben Speis. July, 1940.

21020 VERMICULITE MICA, a hydrous mica, which exfoliates upon heating. From East of Coarse Gold, Madera County, California. In Case 137. Donor: Hugh R. Paden. August, 1940.

21021 AXINITE, $H(Ca,Mn,Fe)_3BAl_2(SiO_4)_4$. From East of Coarse Gold, Madera County, California. In Case 132. Donor: Hugh R. Paden, August, 1940.

LABORATORY

GEORGE L. GARY, Mineral Technologist

Since 1866 many lists have been published showing localities of California minerals. The last one, "Minerals of California," by Adolph Pabst, was published in 1938 by the Division of Mines as Bulletin No. 113.

It is the intention of the Division of Mines to publish in the quarterly new localities for minerals that are received by the laboratory for determination. So that this information may be accurate, it is requested that all specimens submitted for classification be accompanied by a letter giving the exact location where the material was found.

Corrections will also be noted as well as additions when called to our attention.

CORRECTIONS AND ADDITIONS TO BULLETIN No. 113

76. **Molybdenite** is being shipped as a by-product of tungsten from the Pine Creek mine of the U. S. Vanadium Corp. near Bishop, Inyo County.
77. **Scheelite,** a calcium tungstate was found associated with quartz and garnet on Chowchilla Creek, about twenty miles north of Raymond in Mariposa County.
78. Large violet colored crystals of **axinite,** an aluminum and calcium borosilicate, with iron and manganese were found about five miles east of Coarse Gold, Madera County.
79. **Rutile,** a titanium dioxide occurs with lazulite in quartzite near Loope, Alpine County.
80. **Realgar,** an arsenic monosulfide with pyrite in quartz, was reported from Scott Bar, Klamath River, Siskiyou County.
81. **Microcline,** a green potassium and aluminum silicate, was found associated with calcite, garnet and wollastonite, near Mineral King, Tulare County.
82. Irregular and bladed crystalline masses of plum-colored to brownish-blue **axinite,** an aluminum and calcium borosilicate, have been found on the south fork of Erskine Creek, Sec. 6, T. 28 S., R. 33 E., Kern County.
83. **Cordierite,** a magnesium iron aluminum silicate was found with **anthophyllite,** a magnesium and iron silicate, in schist from the Green Mountain district, Mariposa County.
84. **Pyromorphite,** a lead chloro-phosphate, occurs, as prismatic crystals implanted on quartzite, on property operated by the Log Cabin Mines Co., about three miles west of Mono Lake, Mono County.
85. **Altaite,** a lead telluride, occurs about 200 yards east of the Chiquito trail and one-half mile north of Fish Creek, in the North Fork mining district, Madera County.
86. **Enargite** crystals with the prismatic faces vertically striated occur with massive enargite and pyrite on the 300 foot level of the Morningstar mine, in the Mogul mining district, Alpine County.
87. **Microcline,** a green potassium and aluminum silicate, occurs with quartz and biotite mica in the Inyo Range about six miles west of Lone Pine, Inyo County.

LIBRARY

JOHN C. O'BRIEN, Librarian

In addition to the numerous standard works, authoritative information on many phases of the mining and mineral industry is constantly being issued in the form of reports and bulletins by various government agencies.

The library of the Division of Mines contains over six thousand selected volumes on mines, mining and allied subjects, and it is also a repository for reports and bulletins of the technical departments of federal and state governments and of educational institutions, both domestic and foreign.

It is not the dearth of the latter publications, but rather a lack of knowledge of just what has been published and where the reports may be consulted or obtained, that embarrasses the ordinary person seeking specific information.

To assist in making the public acquainted with this valuable source of current technical information, CALIFORNIA JOURNAL OF MINES AND GEOLOGY contains under this heading a list of all books and official reports and bulletins received which pertain particularly to mining in California.

Files of all the leading technical journals will be found in the library, and county and state maps, topographical sheets and geological folios. Current copies of local newspapers published in the mining centers of the state are available for reference.

The library and reading room are open to the public during the usual office hours, when the librarian may be freely called upon for all necessary assistance.

OFFICIAL PUBLICATIONS RECEIVED WHICH HAVE SPECIAL INTEREST OR REFERENCE TO CALIFORNIA

Governmental, National:

U. S. Geological Survey:

Bulletins:

914 Microscopic Determination of the Ore Minerals.
915A Geophysical Abstracts—January-March, 1939.

Water Supply Papers:

843 The Floods of December, 1937, in Northern California.

Topographic Maps:

Camp Baldy Quadrangle, Los Angeles Co.
Camp Bonita Quadrangle, Los Angeles Co.
Evey Canyon Quadrangle, Los Angeles Co.
Mt. Emma Quadrangle, Los Angeles Co. (Adv. Sheet).
Truckee Quadrangle, California-Nevada.

U. S. Bureau of Mines:

Bulletins:

419 Metal-Mining Practice.
421 The Joseph A. Holmes Safety Association and Its Awards.
423 Mechanical Shoveling in Underground Metal Mines.
426 Quarry Accidents in the U. S., 1937.
428 Metal-Mine Accidents in the U. S., 1938.
430 Coal Mine Accidents in the U. S., 1937.

Miners' Circulars:

40 Some Information in Timbering Bituminous Coal Mines.
41 Accidents from Falls of Rock or Ore in Metal Mines.

Economic Paper:

20 Petroleum Statistics.
21 Trends and Seasonal Variations in Factors Influencing Domestic Motor Field Demand.

Technical Papers:

603 Phenomena in the Ignition of Firedamp by Explosives.
608 Safety Factors in Construction and Ventilation, Wawona Vehicular Tunnel, Yosemite National Park, Calif.
609 Bentonite: Its Properties, Mining, Preparation, and Utilization.
610 Correlation Index to Aid in Interpreting Crude-Oil Analysis.
613 Development in Coal Research and Technology in 1937 and 1938.

Report of Investigations:

3469R Progress Reports—Metallurgical Division. 32. Oredressing Studies. Properties of Suspension Mediums for Float-and-Sink Concentration, by F. D. DeVaney and S. M. Shelton.
3490 Annual Report of the Explosives Division, Fiscal Year 1939, by Wilbert J. Huff.
3491 Progress Reports—Metallurgical Division. 37. Electrometallurgical Investigations, by J. Koster and M. B. Royer.
3496 Ventilation of Manholes. 4. Effect of Vertical Ducts in Combination with Openings in Manhole Covers on the Natural Ventilation, by G. W. Jones, W. E. Miller, and John Campbell.
3498 Hydrogenation and Petrography of Home Low-Rank Coals from the Western United States.
3500 Progress Reports—Metallurgical Division. Electrometallurgical Investigations. Electrolytic Method for the Production of Calcium Boride, by J. Koster, R. G. Knickerbocker, and A. L. Fox.
3502 Time Study Analyses. Progress Report 3. Quarry Drilling, by J. R. Thoenen and E. J. Lintner.
3503 A Polarizing Comparison—Microscope for use in Petrographic Measurements, by George T. Faust.
3504 Phenomena Observed during the Prolonged Oxidation of Anthracite, by G. S. Scott and G. W. Jones.
3505 Relationship of Ash-Fusion Temperatures of Coal and Coke, by D. A. Reynolds.
3506 Studies of Roof Movement in Coal Mines. 3. Gibson Mine of the Hillman Coal & Coke Co., by E. R. Maize, Edward Thomas, and H. P. Greenwald.
3507 Gaseous Products from Explosives. 1. Some Factors Affecting Test Results, by John C. Holtz.
3508 Diesel Engines Underground. 1. Composition of Exhaust Gas from Engines in Proper Mechanical Condition, by John C. Holtz, L. B. Berger, M. A. Elliott, and H. H. Schrenk.
3509 Stemming in Metal Mines, Progress Report 1, by John A. Johnson, Wing G. Agnew, and McHenry Mosier.
3510 Cushioned Blasting. 1. Orienting Studies, by A. R. T. Denues.
3511 Explosive Properties of Cyclopropane: Prevention of Explosions by Dilution with Inert Gases, by G. W. Jones, R. E. Kennedy, and G. J. Thomas.

3512 Contributions to the Art of Smelting Lead Products, by Virgil Miller, R. Bainbridge, and R. Ellison.
3513 Concentration of Manganosiderite Ore from Leadville, Colorado, by F. D. Devaney and S. M. Shelton.
3514 Equilibrium Cell for Investigating Properties of Fluids from Petroleum and Natural-Gas Reservoirs (with a section on hypothetical phase relations of natural hydrocarbon mixtures) by Kenneth Eilerts, R. Vincent Smith, and R. C. Wright.
3515 Ore-Testing Studies. Primarily Precious Metals, by Edmund S. Leaver, Jesse A. Woolf, and A. P. Towne.
3516 Darkening Light-Color Soils with Coal-Mine Waste.
3517 Determination of Total Water-soluble Chlorides in Petroleum, by J. W. Horne and Lloyd F. Christianson.
3518 An Experimental Study of the Ignition of Firedamp-air Mixtures by Explosives, by Etienne Audibert.
3519 Underground Transportation of Coal, Progress Report 1, by Albert L. Toenges and Frank A. Jones.
3520 Quantitative Analysis by X-ray Diffraction. 1. Determination of Quartz, by James W. Ballard, H. I. Oshry, and H. H. Schrenk.
3521. Measurement of Pressures on Rock Pillars in Underground Mines, Part II, by Leonard Obert.
3522 Staining of Clay Minerals as a Rapid Means of Identification in Natural and Beneficiated Products, with a General Discussion on Staining Technique, by George T. Faust.
3523 Differential Grinding of Alabama Iron Ores for Gravity Concentration.
3524 Cooperative Fuel Research Motor-Gasoline Survey, Winter 1939-40, by E. C. Lane.
3525 Progress Reports—Metallurgical Division. 40 Benefication of Boron Minerals. Benefication of Boron Minerals by Flotation as Boric Acid, by R. G. Knickerbocker and F. K. Shelton. Production of Calcium Borate from Colemanite by Carbonic Acid Leach, by R. G. Knickerbocker, A. L. Fox, and L. A. Yerkes.
3526 National Safety Competition of 1939, by W. W. Adams and T. D. Lawrence.
3527 Diesel Locomotives in Gassy Mine Workings of Belgium, by Ad. Breyre, Director of the Institut National des Mines, and J. Fripiat, Principal Inspector of Mines, Belgium.
3528 Stemming in Metal Mines. Progress Report 2.
3529 Tests of Salt as a Substitute for Rock Dust in the Prevention of Coal-Dust Explosions in Mines, by H. P. Greenwald, H. C. Howarth, and Irving Hartmann.
3530 A Twenty Years' Survey of the Use of Sheathed Explosives in Belgium.
3531 Air Flow at Discharge of Fan-Pipe Lines in Mines, Part 1. 10-inch line in Development End.
3534 Study of Brine-Disposal Systems in Illinois Oil Fields.

Information Circulars:

6312 Radium.
6751R Onyx Marble and Travertine.
7091 Utilization of Natural Gas for Chemical Products.
7095 Aerial Tramways in the Metal-Mining Industry. Part 2. Construction and Operating Costs, by O. H. Metzger.
7096 Open-pit Mining and Milling Methods and Costs at the Yellow Aster Mine, Randsburg, California by A. W. Frolli.
7098 Cooling Mine Air During Summer Months to Prevent Roof Falls, by C. A. Herbert.
7101 Mining and Milling Methods and Costs in the Alma District, Colorado, by Jos. R. Guiteras.
7102 The Cement Industry of Latin America, by Oliver Bowles and R. B. Miller.
7106 Nonmetallic Mineral Industries in 1939, by Paul M. Tyler and Oliver Bowles.
7107 Cutting and Polishing Stones, by M. W. von Bernewitz and Frank Hess.

7108 Utilization of Natural Gas for Chemical Products, by Harold M. Smith.
7110 List of Permissible Mine Equipment Approved to January 1, 1940, by L. C. Ilsley.
7111 Operations at the Haile Gold Mine, Kershaw, S. C. by Edmund Newton, D. B. Gregg, and McHenry Mosier.
7112 Mining of Feldspar and Associated Minerals in the Southern Black Hills of South Dakota, by Jos. R. Guiteras.
7113 Methods of Sampling and Analyzing Coal-Mine Dusts for Incombustible Content, by C. W. Owings, W. A. Selvig, and H. P. Greenwald.
7114 Some Information on Reduction of Quarry Accidents, by Frank E. Cash and Forrest H. Shuford.
7115 Cars for Transporting Explosives, by C. W. Owings.
7116 The New Metallurgical Experiment Station for the Bureau of Mines, United States Department of the Interior, at Salt Lake City, Utah, by R. S. Dean and Cresap Moss.
7117 The Potash Situation, by Bertrand L. Johnson.
7118 More Jobs for Minerals, by Paul M. Tyler.
7119 Mining and Milling Methods and Costs at the Ash Peak Mine of the Veta Mines, Inc., Duncan, Ariz., by Herbert L. Lines.
7120 Fatalities caused by Electric Contacts in Alabama Coal Mines, 1925-39, by Frank E. Cash.
7121 Minerals Used in Welding, by Oliver C. Ralston and M. W. von Bernewitz.
7122 Novel Device for Collecting Air Samples in Inaccessible Places, by W. J. Fene.
7123 Mining and Milling Methods and Costs at Knob Hill Mine, Republic, Washington, by Corwin L. Cooper.
7124 Petroleum Refineries, including Cracking Plants, in the United States, January 1, 1940, by G. R. Hopkins and E. W. Cochrane.
7125 Mineral Industries Survey of the U. S. Colorado, Lake County. Possibilities of Manganese Production at Leadville, Colo.
7126 Natural-Gasoline Plants in the United States, January 1, 1940, by G. R. Hopkins and E. M. Seeley.
7127 Portable Cabinets for Materials Used in Mineral Determinations, by Kenneth G. Skinner.
7128 Construction of the Bingham-Copperfield Vehicular Tunnel, by L. S. Breckon.
7129 Petrographic Methods and Their Application to the Examination of Nonmetallic Materials, by George T. Faust and Alton Gabriel.
7130 Testing Respiratory Protective Equipment for Approval, by H. H. Schrenk.
7131 Use of Wetting Agents for Allaying Coal Dust in Mines.
7132 Work of the Bureau of Mines Safety Cars in the Pennsylvania Anthracite Region from 1934 to 1939.

PUBLICATIONS RECEIVED CURRENTLY AND FORMER REPORTS AVAILABLE FOR REFERENCE

Governmental, State.

Alabama Geological Survey, University.
Arizona Bureau of Mines, Tucson.
Arkansas Geological Survey, Little Rock.
Colorado Bureau of Mines, Denver.
Connecticut Geological and Natural History Survey, Hartford.
Florida Department of Conservation, Tallahassee.
Georgia Division of Geology, Atlanta.
Idaho Bureau of Mines and Geology, Moscow.
Illinois Geological Survey, Urbana.
Iowa Geological Survey, Des Moines.
State Geological Survey of Kansas, Lawrence.
Kentucky Geological Survey, Frankfort.
Louisiana Department of Conservation, New Orleans.
Maine State Geologist, Augusta.

Maryland Geological Survey, Baltimore.
Michigan Geological Survey, Lansing.
Minnesota Geological Survey, Minneapolis.
Mississippi State Geological Survey, University.
Missouri Bureau of Geology & Mines, Rolla.
Montana Bureau of Mines and Geology, Butte.
Nebraska Geological Survey, Lincoln.
Nevada State Bureau of Mines, Reno.
New Jersey Department of Conservation and Development, Trenton.
New Mexico Bureau of Mines and Mineral Resources, Socorro.
North Carolina Geological & Economic Survey, Chapel Hill.
North Dakota Geological Survey, Grand Forks.
Ohio Geological Survey, Columbus.
Oklahoma Geological Survey, Norman.
Oregon State Department of Geology and Mineral Industries, Portland.
Pennsylvania Topographic and Geological Survey, Harrisburg.
South Dakota State Geological Survey, Vermillion.
Tennessee Division of Geology, Nashville.
Texas Bureau of Economic Geology, Austin.
Virginia Geological Survey, University.
Washington State Department of Conservation and Development, Pullman.
West Virginia Geological Survey, Morgantown.
Wisconsin Geological & Natural History Survey, Madison.
Wyoming Geological Survey, Cheyenne.

Governmental, Foreign.

Alberta Research Council, Edmonton.
Argentina Direccion General de Minas y Geologica, Buenos Aires.
British Columbia Minister of Mines, Victoria.
British Museum and Natural History, London.
Canada Department of Mines, Ottawa.
Cuerpo de Ingenieros de Minas y Aguas del Peru, Lima.
Geological Service of Minas Geraes, Bella Horizonte, Brazil.
Geological Survey of Scotland.
Instituto Historica e Geographico Rio de Janeiro.
Museo de Historia Natural de Montevideo, Uruguay.
New South Wales Department of Mines, Sydney, Australia.
New Zealand Geological Survey Branch, Wellington.
Nova Scotia Department of Public Works and Mines, Halifax.
Ontario Department of Mines, Toronto, Canada.
Quebec Bureau of Mines, Quebec.
Queensland Department of Mines, Brisbane, Australia.
South Australia Department of Mines, Adelaide.
Transvaal Chamber of Mines, Johannesburg, South Africa.
Western Australia, Geological Survey, Perth.

Societies and Educational Institutions.

Academia de Ciencias y Artes de Barcelona, Spain.
Academy of Natural Sciences, of Philadelphia.
American Association of Petroleum Geologists, Tulsa, Oklahoma.
American Geographical Society of New York.
American Institute of Mining and Metallurgical Engineers, New York.
American Journal of Science, New Haven, Conn.
American Philosophical Society, Philadelphia.
Australian Museum, Sydney.
California Academy of Sciences, San Francisco.
Carnegie Institution of Washington.
Cleveland Museum of Natural History, Cleveland, Ohio.
Colorado College Publications, Colorado Springs.
Colorado Scientific Society, Denver.
Commonwealth Club, San Francisco.
Economic Geology, Lancaster, Pa.
Field Museum of Natural History, Chicago.

Franklin Institute of the State of Pennsylvania, Lancaster, Pa.
Geological Society of America, Columbia University, New York.
Geographical Society of London.
Institution of Mining and Metallurgy, London.
Instituto Geologico de Mexico, Mexico, D. F.
Journal of Geology, Chicago.
Mineralogical Society of America, Menasha, Wisconsin.
Michigan College of Mining and Technology, Houghton.
Mining and Metallurgical Society of America, New York.
Museu Nacional, Rio de Janeiro.
National Research Council, Washington, D. C.
New York Academy of Sciences, New York.
New York State Museum, Albany.
Pennsylvania State College, State College.
Philippine Journal of Science, Manila.
Royal Society of South Australia, Adelaide.
Seismological Society of America, Stanford University.
Sierra Club, San Francisco.
Society of Economical Paleontologists and Mineralogists, Fort Worth, Texas.
Southern California Acadamy of Sciences, Los Angeles.
University of California Publications in Engineering, Berkeley.
University of California Publications in Geography, Berkeley.
University of California Publications in Geology, Berkeley.
University of Harvard, Department of Mineralogy and Petrography, Cambridge, Mass.

Current Magazines on File.

For the convenience of persons wishing to consult the technical magazines in the reading room, a list of those on file is appended:

Asbestos, Philadelphia, Pennsylvania.
Brick and Clay Record, Chicago.
California Journal of Development, San Francisco.
California Mining Journal, Auburn.
California Oil World, Los Angeles.
California Safety News, San Francisco.
Canadian Mining Journal, Gardenvale, Quebec.
Chemical and Metallurgical Engineering, New York City.
Chemical Engineering and Mining Review, Melbourne, Australia.
Civil Engineering, New York City.
Colorado School of Mines, Golden, Colorado.
Conservationist, Sacramento, California.
Engineering and Mining Journal, New York City.
Fuel Oil, Chicago, Illinois.
Fusion Facts, Whittier, California.
Gemmologist, London.
Gold, Toronto, Canada.
Grizzly Bear, Los Angeles.
Hercules Mixer, Wilmington, Delaware.
Independent Monthly, Tulsa, Oklahoma.
Lubrication, The Texas Co., New York City.
Metals and Alloys, Pittsburgh, Pennsylvania.
Mine and Mill World Digest, San Francisco.
Mining and Contracting Review, Salt Lake City.
Mineralogist, Portland, Oregon.
Mining Congress Journal, Washington, D. C.
Mining and Industrial News, San Francisco.
Mining and Geological Journal, Melbourne, Victoria, Australia.
Mining Journal, London.
Mining Journal, Phoenix, Arizona.
Mining and Metallurgy, New York City.
Mining Review, Salt Lake City.
Mining World, Seattle.
Nevada Mining Bulletin, Las Vegas, Nevada.

Nickel Steel Topics, New York City.
Northwest Mining, Spokane, Washington.
Northwest Science, Cheney, Washington.
Oil and Gas Journal, Tulsa, Oklahoma.
Oil, Paint and Drug Reporter, New York City.
Oil Weekly, Houston, Texas.
Pacific Purchaser, San Francisco.
Pacific Chemical and Metallurgical Industries, San Francisco.
Petroleum World, Los Angeles.
Queensland Government Mining Journal, Brisbane, Australia.
Rock Products, Chicago.
Rocks and Minerals, Peekskill, New York.
Scientific American, New York City.
Southwest Builder and Contractor, Los Angeles.
Stabilizer, Los Angeles.
Standard Oil Bulletin, San Francisco.
Stone, New York City.
Western Mining News, San Francisco.

Newspapers.

The following papers are received and kept on file in the library:

Alaska Weekly, Seattle, Washington.
Amador Dispatch, Jackson, California.
Banner, Sonora, California.
Barstow Printer, Barstow, California.
Bridgeport Chronicle-Union, Bridgeport, California.
Calaveras Californian, Angels Camp, California.
Calaveras Prospect, San Andreas, California.
Colusa Sun-Herald, Colusa, California.
Daily Commercial News, San Francisco, California.
Del Norte Triplicate, Crescent City, California.
Denver Mining Record, Denver, Colorado.
Georgetown Gazette, Georgetown, California.
Humboldt Beacon, Humboldt.
Inyo Independent, Independence, California.
Inyo Register, Bishop, California.
Las Vegas Age, Las Vegas, Nevada.
Livermore Herald, Livermore, California.
Los Angeles Times, Los Angeles, California.
Mariposa Gazette, Mariposa, California.
Mercury Register, Oroville, California.
Mining Press, Reno.
Mohave Miner, Kingman, Arizona.
Mojave-Randsburg Record, Mojave, California.
Morning Union, Grass Valley, California.
Mountain Messenger, Downieville, California.
Needles Nugget, Needles, California.
Nevada Mining Bulletin, Las Vegas, Nevada.
Oil Marketer, Bayonne, New Jersey.
Owens Valley Progress Citizen, Lone Pine.
Placer Herald, Auburn, California.
Plumas Independent, Quincy, California.
Randsburg Times, Randsburg.
San Diego News, San Diego, California.
Shasta Courier, Redding, California.
Siskiyou News, Yreka, California.
Tehachapi News, Tehachapi, California.
Terra Bella News, Terra Bella, California.
Tuolumne Independent, Sonora, California.
Tuolumne Prospector, Tuolumne, California.
Union Democrat, Sonora, California.
Ventura County News, Ventura, California.
Waterford News, Waterford, California.

Weekly Trinity Journal, Weaverville, California.
Western Mineral Survey, Salt Lake City, Utah.
Western Sentinel, Etna Mills, California.

Books:

The American Philosophical Society Year Book, 1939.
Canadian Mines Handbook—1940.
Mineral Map of Europe—Geol. Dept. of the Pure Oil Co.

EMPLOYMENT SERVICE

Following the establishment of the Mining Division branch offices in 1919, a free technical employment service was offered as a mutual aid to mine operators and technical men for the general benefit of the mineral industry.

Briefly summarized, men desiring positions are registered, the cards containing an outline of the applicant's qualifications, position wanted, salary desired, etc., and as notices of 'positions open' are received, the names and addresses of all applicants deemed qualified are sent to the prospective employer for direct negotiations.

Telephone and telegraphic communications are also given immediate attention.

Technical men, or those qualified for supervisory positions, and vacancies of like nature only, are registered, as no attempt will be made to supply common mine and mill labor.

Registration cards for the use of both prospective employers and employees may be obtained upon request, and a cordial invitation is extended to the industry to make free use of the facilities afforded. Parties interested should communicate direct with our San Francisco office.

PRODUCERS AND CONSUMERS

The producer and consumer of mineral products are mutually dependent upon each other for their prosperity, and one of the most direct aids rendered by this Division to the mining industry in the past has been that of bringing producers and consumers into direct touch with each other.

This work has been carried on largely by correspondence, supplemented by personal consultation. Lists of buyers of all the commercial minerals produced in California have been made available to producers upon request, and likewise the owners of undeveloped deposits of various minerals, and producers of them, have been made known to those looking for raw mineral products.

When the publication of *Mining in California* was on a monthly basis, current inquiries from buyers and sellers were summarized and lists of mineral products or deposits 'wanted' or 'for sale' included in each issue.

It is important that inquiries of this nature reach the mining public as soon as possible and in order to avoid the delay incident to the present quarterly publication of CALIFORNIA JOURNAL OF MINES AND GEOLOGY, these lists are now issued monthly in the form of a mimeographed sheet under the title of 'Commercial Mineral Notes,' and sent to those on the mailing list of CALIFORNIA JOURNAL OF MINES AND GEOLOGY.

PUBLICATIONS OF THE DIVISION OF MINES

During the past fifty-six years, in carrying out the provisions of the organic act creating the former California State Mining Bureau, there have been published many reports, bulletins and maps which go to make up a library of detailed information on the mineral industry of the State, a large part of which could not be duplicated from any other source.

One feature that has added to the popularity of the publications is that many of them have been distributed without cost to the public, and even the more elaborate ones have been sold at a price which barely covers the cost of printing.

Owing to the fact that funds for the advancing of the work of this department have usually been limited, the reports and bulletins mentioned are printed in limited editions many of which are now entirely exhausted.

Copies of such publications are available for reference, however, in the offices of the Division of Mines, in the Ferry Building, San Francisco; State Building, Los Angeles; State Office Building, Sacramento; Redding; and Division of Oil and Gas at Santa Barbara, Santa Paula, Taft, Bakersfield, Coalinga. They may also be found in many public, private and technical libraries in California and other states and foreign countries.

A catalog of all publications from 1880 to 1917, giving a synopsis of their contents, is issued as Bulletin No. 77.

Publications in stock may be obtained postpaid by addressing the San Francisco, Los Angeles or Sacramento offices and enclosing the requisite amount.

Remittances of stamps in an amount not to exceed 26 cents, currency or coin will be accepted at sender's risk. Payment is preferred in the form of money orders.

Money orders should be made payable to the Division of Mines.

NOTE.—The Division of Mines frequently receives requests for some of the early Reports and Bulletins now out of print, and it will be appreciated if parties having such publications and wishing to dispose of them will advise this office.

Write for latest revised price list.

7—90678

REPORTS

Asterisks (**) indicate the publication is out of print.	Price (including postage and sales tax)
**First Annual Report of the State Mineralogist, 1880, 43 pp. Henry G. Hanks	----
**Second Annual Report of the State Mineralogist, 1882, 514 pp., 4 illustrations, 1 map. Henry G. Hanks	----
**Third Annual Report of the State Mineralogist, 1883, 111 pp., 21 illustrations. Henry G. Hanks	----
**Fourth Annual Report of the State Mineralogist, 1884, 410 pp., 7 illustrations. Henry G. Hanks	----
**Fifth Annual Report of the State Mineralogist, 1885, 234 pp., 15 illustrations, 1 geological map. Henry G. Hanks	----
Sixth Annual Report of the State Mineralogist, Part I, 1886, 145 pp., 3 illustrations, 1 map. Henry G. Hanks--Price $0.75, sales tax $0.02	$0.77
Part II, 1887, 222 pp., 36 illustrations. William Irelan, Jr. Price $0.75, sales tax $0.02	.77
**Seventh Annual Report of the State Mineralogist, 1887, 315 pp. William Irelan, Jr.	----
**Eighth Annual Report of the State Mineralogist, 1888, 948 pp., 122 illustrations. William Irelan, Jr.	----
**Ninth Annual Report of the State Mineralogist, 1889, 352 pp., 57 illustrations, 2 maps. William Irelan, Jr.	----
**Tenth Annual Report of the State Mineralogist, 1890, 983 pp., 179 illustrations, 10 maps. William Irelan, Jr.	----
Eleventh Report (First Biennial) of the State Mineralogist, for the two years ending September 15, 1892, 612 pp., 73 illustrations, 4 maps. William Irelan, Jr.--Price $1.50, sales tax $0.05	1.55
**Twelfth Report (Second Biennial) of the State Mineralogist, for the two years ending September 15, 1894, 541 pp., 101 illustrations, 5 maps. J. J. Crawford	----
**Thirteenth Report (Third Biennial) of the State Mineralogist, for the two years ending September 15, 1896, 726 pp., 93 illustrations, 1 map. J. J. Crawford	----
Chapters of the State Mineralogist's Report, XIV Biennial Period, 1913-1914, Fletcher Hamilton:	
**Mines and Mineral Resources, Amador, Calaveras and Tuolumne Counties, 172 pp., paper	----
Mines and Mineral Resources, Colusa, Glenn, Lake, Marin, Napa, Solano, Sonoma and Yolo Counties, 208 pp., paper Price $0.75, sales tax $0.02	.77
**Mines and Mineral Resources, Del Norte, Humboldt and Mendocino Counties, 59 pp., paper	----
**Mines and Mineral Resources, Fresno, Kern, Kings, Madera, Mariposa, Merced, San Joaquin and Stanislaus Counties, 220 pp., paper	----
**Mines and Mineral Resources of Imperial and San Diego Counties, 113 pp., paper	----
**Mines and Mineral Resources, Shasta, Siskiyou and Trinity Counties, 180 pp., paper	----
**Fourteenth Report of the State Mineralogist, for the Biennial Period 1913-1914, Fletcher Hamilton, 1915: A General Report on the Mines and Mineral Resources of Amador, Calaveras, Tuolumne, Colusa, Glenn, Lake, Marin, Napa, Solano, Sonoma, Yolo, Del Norte, Humboldt, Mendocino, Fresno, Kern, Kings, Madera, Mariposa, Merced, San Joaquin, Stanislaus, San Diego, Imperial, Shasta, Siskiyou and Trinity Counties, 974 pp., 275 illustrations, cloth	----
Chapters of the State Mineralogist's Report, XV Biennial Period, 1915-1916, Fletcher Hamilton:	
**Mines and Mineral Resources, Alpine, Inyo and Mono Counties, 176 pp., paper	----
Mines and Mineral Resources, Butte, Lassen, Modoc, Sutter and Tehama Counties, 91 pp., paper--Price $0.75, sales tax $0.02	.77

REPORTS—Continued

Asterisks (**) indicate the publication is out of print.	Price (including postage and sales tax)
Mines and Mineral Resources, El Dorado, Placer, Sacramento and Yuba Counties, 198 pp., paper————Price $0.75, sales tax $0.02	$0.77
Mines and Mineral Resources, Monterey, San Benito, San Luis Obispo, Santa Barbara and Ventura Counties, 183 pp., paper———— Price $0.75, sales tax $0.02	.77
**Mines and Mineral Resources, Los Angeles, Orange and Riverside Counties, 136 pp., paper————	----
**Mines and Mineral Resources, San Bernardino and Tulare Counties, 186 pp., paper ————	----
**Fifteenth Report of the State Mineralogist, for the Biennial Period 1915-1916, Fletcher Hamilton, 1917: A General Report on the Mines and Mineral Resources of Alpine, Inyo, Mono, Butte, Lassen, Modoc, Sutter, Tehama, Placer, Sacramento, Yuba, Los Angeles, Orange, Riverside, San Benito, San Luis Obispo, Santa Barbara, Ventura, San Bernardino and Tulare Counties, 990 pp., 413 illustrations, cloth————	----
Chapters of the State Mineralogist's Report XVI, Biennial Period, 1917-1918, Fletcher Hamilton:	
Mines and Mineral Resources of Nevada County, 270 pp., paper———— Price $1.00, sales tax $0.03	1.03
Mines and Mineral Resources of Plumas County, 188 pp., paper———— Price $0.75, sales tax $0.02	.77
Mines and Mineral Resources of Sierra County, 144 pp., paper———— Price $0.75, sales tax $0.02	.77
Seventeenth Report of the State Mineralogist, 1920, 'Mining in California during 1920,' Fletcher Hamilton; 562 pp., 71 illustrations, cloth———— Price $2.50, sales tax $0.08	2.58
Eighteenth Report of the State Mineralogist, 1922, 'Mining in California,' Fletcher Hamilton. Chapters published monthly beginning with January, 1922:	
**January, **February, March, April, **May, June, July, August, September, October, **November, December, 1922————	------
Chapters of Nineteenth Report of the State Mineralogist, 'Mining in California,' Fletcher Hamilton and Lloyd L. Root. January, February, March, September, 1923————Price $0.40, sales tax $0.01	.41
Chapters of Twentieth Report of the State Mineralogist, 'Mining in California,' Lloyd L. Root. Published quarterly. January, April, July, October, 1924, per copy————Price $0.40, sales tax $0.01	.41
Chapters of Twenty-first Report of the State Mineralogist, 'Mining in California,' Lloyd L. Root. Published quarterly:	
January, 1925, Mines and Mineral Resources of Sacramento, Monterey and Orange Counties————Price $0.40, sales tax $0.01	.41
April, 1925, Mines and Mineral Resources of Calaveras, Merced, San Joaquin, Stanislaus and Ventura Counties———— Price $0.40, sales tax $0.01	.41
July, 1925, Mines and Mineral Resources of Del Norte, Humboldt and San Diego Counties————Price $0.40, sales tax $0.01	.41
**October, 1925, Mines and Mineral Resources of Siskiyou, San Luis Obispo and Santa Barbara Counties————	----
Chapters of Twenty-second Report of the State Mineralogist, 'Mining in California,' Lloyd L. Root. Published quarterly:	
**January, 1926, Mines and Mineral Resources of Trinity and Santa Cruz Counties ————	----
April, 1926, Mines and Mineral Resources of Shasta, San Benito and Imperial Counties ————Price $0.40, sales tax $0.01	.41
July, 1926, Mines and Mineral Resources of Marin and Sonoma Counties Price $0.40, sales tax $0.01	.41
**October, 1926, Mines and Mineral Resources of El Dorado and Inyo Counties, also report on Minaret District, Madera County————	----
Chapters of Twenty-third Report of the State Mineralogist, 'Mining in California,' Lloyd L. Root. Published quarterly:	

REPORTS—Continued

Asterisks (**) indicate the publication is out of print.	Price (including postage and sales tax)
January, 1927, Mines and Mineral Resources of Contra Costa County; Santa Catalina Island. Price $0.40, sales tax $0.01	$0.41
April, 1927, Mines and Mineral Resources of Amador and Solano Counties. Price $0.40, sales tax $0.01	.41
**July, 1927, Mines and Mineral Resources of Placer and Los Angeles Counties	--
October, 1927, Mines and Mineral Resources of Mono County. Price $0.40, sales tax $0.01	.41
Chapters of Twenty-fourth Report of the State Mineralogist, 'Mining in California,' Lloyd L. Root. Published quarterly:	
January, 1928, Mines and Mineral Resources of Tuolumne County. Price $0.40, sales tax $0.01	.41
April, 1928, Mines and Mineral Resources of Mariposa County. Price $0.40, sales tax $0.01	.41
**July, 1928, Mines and Mineral Resources of Butte and Tehama Counties	----
October, 1928, Mines and Mineral Resources of Plumas and Madera Counties. Price $0.40, sales tax $0.01	.41
Chapters of Twenty-fifth Report of the State Mineralogist, 'Mining in California,' Walter W. Bradley. Published quarterly:	
January, 1929, Mines and Mineral Resources of Lassen, Modoc and Kern Counties; also on Special Placer Machines. Price $0.40, sales tax $0.01	.41
**April, 1929, Mines and Mineral Resources of Sierra, Napa, San Francisco and San Mateo Counties	----
July, 1929, Mines and Mineral Resources of Colusa, Fresno and Lake Counties. Price $0.40, sales tax $0.01	.41
October, 1929, Mines and Mineral Resources of Glenn, Alameda, Mendocino and Riverside Counties. Price $0.40, sales tax $0.01	.41
Chapters of Twenty-sixth Report of the State Mineralogist, 'Mining in California,' Walter W. Bradley. Published quarterly:	
January, 1930, Mines and Mineral Resources of Santa Clara County; also Barite in California. Price $0.40, sales tax $0.01	.41
**April, 1930, Mines and Mineral Resources of Nevada County; also Mineral Paint Materials in California	----
**July, 1930, Mines and Mineral Resources of Yuba and San Bernardino Counties; also Commercial Grinding Plants in California	----
October, 1930, Mines and Mineral Resources of Butte, Kings and Tulare Counties; also Geology of Southwestern Mono County (Preliminary). Price $0.40, sales tax $0.01	.41
Chapters of Twenty-seventh Report of the State Mineralogist, 'Mining in California,' Walter W. Bradley. Published quarterly:	
January, 1931. Preliminary Report of Economic Geology of the Shasta Quadrangle. Beryllium and Beryl. The New Tariff and Nonmetallic Products. Crystalline Talc. Decorative Effects in Concrete. Price $0.40, sales tax $0.01	.41
April, 1931, Stratigraphy of the Kreyenhagen Shale. Diatoms and Silicoflagellates of the Kreyenhagen Shale. Foraminifera of the Kreyenhagen Shale. Geology of Santa Cruz Island. Price $0.40, sales tax $0.01	.41
**July, 1931. (Yuba, San Bernardino.) Feldspar, Silica, Andalusite and Cyanite Deposits of California. Note on a Deposit of Andalusite in Mono County; its occurrence and chemical importance. Bill creating Trinity and Klamath River Fish and Game District and its effect upon mining	----
October, 1931. (Alpine.) Geology of the San Jacinto Quadrangle south of San Gorgonio Pass, California. Notes on Mining Activities in Inyo and Mono Counties in July, 1931. Price $0.40, sales tax $0.01	.41
Chapters of Twenty-eighth Report of the State Mineralogist, 'Mining in California,' Walter W. Bradley. Published quarterly:	
January, 1932, Economic Mineral Deposits of the San Jacinto Quadrangle. Geology and Physical Properties of Building Stone from Car-	

REPORTS—Continued

Asterisks (**) indicate the publication is out of print. Price (including postage and sales tax)

nel Valley. Contributions to the Study of Sediments. Sediments of Monterey Bay. Sanbornite____________Price $0.40, sales tax $0.01 $0.41

**April, 1932. Elementary Placer Mining Methods and Gold Saving Devices. The Pan, Rocker and Sluice Box. Prospecting for Vein Deposits. Bibliography of Placer Mining________________________ ----

Abstract from April quarterly: Elementary Placer Mining Methods and Gold Saving Devices. Types of Deposits, Simple Equipment. Special Machines. Dry Washing. Black Sand Treatment. Marketing of Products. Placer Mining Areas. Laws. Prospecting for Quartz Veins. Bibliography (mimeographed)__Price $0.25, sales tax $0.01 .26

July-October. (Ventura.) Report accompanying Geologic Map of Northern Sierra Nevada. Fossil Plants in Auriferous Gravels of the Sierra Nevada. Glacial and Associated Stream Deposits of the Sierra Nevada. Jurassic and Cretaceous Divisions in the Knoxville-Shasta Succession of California. Geology of a part of the Panamint Range. Economic Report of a Part of the Panamint Range. Acquiring Mining Claims Through Tax Title. The Biennial Report of State Mineralogist ______________________________Price $0.75, sales tax $0.02 .77

Chapters of Report XXIX, 1933 (quarterly): titled 'California Journal of Mines and Geology,' containing the following:

January-April. Gold Deposits of the Redding and Weaverville Quadrangles. Geologic Formations of the Redding-Weaverville District, Northern California. Geology of Portions of Del Norte and Siskiyou Counties. Applications of Geology to Civil Engineering. The Lakes of California. Discovery of Piedmontite in the Sierra Nevada. Tracing 'Buried River' Channel Deposits by Geomagnetic Methods. Geologic Map of Redding-Weaverville District, showing gold mines and prospects. Geologic map showing various mines and prospects of part of Del Norte and Siskiyou Counties________________________ Price $1.00, sales tax $0.03 1.03

July-October. Gold Resources of Kern County. Limestone Deposits of the San Francisco Region. Limestone Weathering and Plant Associations of the San Francisco Region. Booming, Death Valley National Monument, California. Placer Mining Districts, Senate Bill 480. Navigable Waters, Assembly Bill 1543_________________ Price $1.00, sales tax $0.03 1.03

Chapters of Report XXX, 1934 (quarterly): titled 'California Journal of Mines and Geology,' containing the following:

January. Resurrection of Early Surfaces in the Sierra Nevada. Geology and Mineral Resources of Northeastern Madera County. Geology and Mineral Deposits of Laurel and Convict Basins, Southwestern Mono County. Notes on Sampling as Applied to Gold Quartz Deposits___ Price $0.60, sales tax $0.02 .62

April-July. Elementary Placer Mining in California and Notes on the Milling of Gold Ores__________________Price $1.00, sales tax $0.03 1.03

October. Current Mining Developments in Northern California. Current Mining Activity in Southern California. Geology and Mineral Resources of the Julian District, San Diego County. Geology and Mineral Resources of Elizabeth Lake Quadrangle. Dry Placers of Northern Mojave Desert. Biennial Report of State Mineralogist. Assessment Work Within Withdrawn Areas_____________________ Price $0.60, sales tax $0.02 .62

Chapters of Report XXI, 1935 (quarterly): titled 'California Journal of Mines and Geology,' containing the following:

January. Review of Gold Mining in East-Central, 1934. Current Mining Activities in the San Francisco District with Special Reference to Gold. Geological Investigation of the Clays of Riverside and Orange Counties, Southern California. Information regarding Mining Loans by the Reconstruction Finance Corporation_____________ Price $0.60, sales tax $0.02 .62

REPORTS—Continued

Asterisks (**) indicate the publication is out of print. Price (including postage and sales tax)

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OTHER MAPS—Continued

Asterisks (**) indicate the publication is out of print.	Price (including postage and sales tax)
**Map of Mother Lode Region	----
**Map of Desert Region of Southern California	----
Map of Minaret District, Madera County—Price $0.25, sales tax $0.01	$0.26
**Map of Copper Deposits in California	----
**Map of Calaveras County	----
**Map of Plumas County	----
**Map of Trinity County	----
**Map of Tuolumne County	----
**Geographical Map of Inyo County. Scale 1 inch equals 4 miles	----
**Map of California accompanying Bulletin No. 89, showing generalized classification of land with regard to oil possibilities. Map only, without Bulletin	------
Geologic Map of California, 1916. Scale 1 inch equals 12 miles. Shows railroads, highways, post offices and other towns. Geological details lithographed in 23 colors. Mounted—Price $2.75, sales tax $0.08	2.83
**Unmounted	----
Geologic Map of California, 1938. Scale 8 miles per inch. Lithographed in 80 distinguishing colors and patterns showing geologic units. In 6 sections, each 32 in. x 42 in. Set of 6 sheets, unmounted. Sheets not sold separately—Price $4.00, sales tax $0.12	4.12
**Topographic Map of Sierra Nevada Gold Belt, showing distribution of auriferous gravels, accompanying Bulletin No. 92. In 4 colors (also sold singly)	----
Geologic Map of Northern Sierra Nevada, showing Tertiary River Channels and Mother Lode Belt accompanying July-October Chapter of Report XXVIII of the State Mineralogist. (Sold singly)—Price $0.40, sales tax $0.01	.41
Map of Northern California, showing rivers and creeks which produced placer gold in 1932—Price $0.25, sales tax $0.01	.26
Mother Lode Geologic and claim maps in 5 county sections: El Dorado, Amador, Calaveras, Tuolumne and Mariposa. Single sections .25c. Set of 5—Price $1.00, sales tax $0.03	1.03
Map of Mariposa County, showing principal gold mines—Price $0.25, sales tax $0.01	.26
Geologic Map of Elizabeth Lake Quadrangle, Los Angeles and Kern Counties (accompanying October Chapter of Report XXX), sold separately—Price $0.25, sales tax $0.01	.26
Map of Western Portion of Siskiyou County Showing Location of Principal Gold Mines (accompanying July Chapter of Report XXXI), sold separately—Price $0.25, sales tax $0.01	.26
Geologic Map of Redding and Weaverville Quadrangles Showing Location of Gold Mines—Price $0.25, sales tax $0.01	.26
Map of Ancient Channel System, Calaveras County—Price $0.25, sales tax $0.01	.26
Map of Ancient Channels Between San Andreas and Mokelumne Hill—Price $0.25, sales tax $0.01	.26
Elizabeth Lake Quadrangle—Price $0.25, sales tax $0.01	.26
Minaret—Price $0.25, sales tax $0.01	.26
Perris Block Geologic—Price $0.25, sales tax $0.01	.26
Plumas County Geologic—Price $0.25, sales tax $0.01	.26
Shasta County Geologic—Price $0.25, sales tax $0.01	.26
El Dorado County—Price $0.25, sales tax $0.01	.26

OIL FIELD MAPS

The maps are revised from time to time as development work advances and ownerships change.

Map No. 1—Sargent, Santa Clara County—Price $0.75, sales tax $0.02	$0.77
Map No. 2—Santa Maria, including Cat Canyon and Los Alamos—Price $1.25, sales tax $0.04	1.29

OIL FIELD MAPS—Continued

The maps are revised from time to time as development work advances and ownerships change.

	Price (including postage and sales tax)
Map No. 3—Santa Maria, including Casmalia and Lompoc — Price $1.25, sales tax $0.04	$1.29
Map No. 4—Brea Olinda and (East Portion) Coyote Hills, Los Angeles and Orange Counties — Price $1.25, sales tax $0.04	1.29
Map No. 6—Salt Lake-Beverly Hills, Los Angeles County — Price $1.25, sales tax $0.04	1.29
Map No. 7—Sunset and San Emidio, Kern County — Price $1.25, sales tax $0.04	1.29
Map No. 8—South Midway and Buena Vista Hills, Kern County — Price $1.25, sales tax $0.04	1.29
Map No. 9—North Midway and McKittrick, Kern County — Price $1.25, sales tax $0.04	1.29
Map No. 10—Belridge and McKittrick Front, Kern County — Price $1.25, sales tax $0.04	1.29
Map No. 11—Lost Hills and North Belridge, Kern County — Price $1.25, sales tax $0.04	1.29
Map No. 12—Devils Den, Kern County — Price $1.00, sales tax $0.03	1.03
Map No. 13—Kern River, Kern County — Price $1.00, sales tax $0.03	1.03
Map No. 14—Coalinga and E. Coalinga Extension, Fresno County — Price $1.50, sales tax $0.05	1.55
Map No. 15—Elk Hills, Kern County — Price $1.25, sales tax $0.04	1.29
Map No. 16—Ventura-Ojai, Ventura County — Price $1.25, sales tax $0.04	1.29
Map No. 17—Santa Paula-Sespe, including Bardsdale, South Mountain and Camarillo, Ventura County — Price $1.25, sales tax $0.04	1.29
Map No. 18—Piru-Simi-Newhall, Ventura County — Price $1.25, sales tax $0.04	1.29
Map No. 19—Arroyo Grande, San Luis Obispo County — Price $1.00, sales tax $0.03	1.03
Map No. 20—Long Beach, Los Angeles County — Price $1.75, sales tax $0.05	1.80
Map No. 21-B—Portion of District No. 5, showing boundaries of oil fields—Fresno, Kings and Kern Counties — Price $1.00, sales tax $0.03	1.03
Map No. 21-C—Portion of District No. 4, showing boundaries of oil fields—Kern, Kings and Tulare Counties — Price $1.25, sales tax $0.04	1.29
Map No. 22—Portion of District No. 3, showing boundaries of oil fields—Santa Barbara County — Price $0.75, sales tax $0.02	.77
Map No. 23—Portion of District No. 2, showing boundaries of oil fields—Ventura County — Price $1.00, sales tax $0.03	1.03
Map No. 24—Portion of District No. 1, showing boundaries of oil fields—Los Angeles and Orange Counties — Price $1.00, sales tax $0.03	1.03
Map No. 26—Huntington Beach, Orange County — Price $1.50, sales tax $0.05	1.55
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Map No. 31—Inglewood, Los Angeles County — Price $1.25, sales tax $0.04	1.29
Map No. 32—Seal Beach, Los Angeles and Orange Counties — Price $1.25, sales tax $0.04	1.29
Map No. 33—Rincon, Ventura County — Price $1.50, sales tax $0.05	1.55
Map No. 34—Mt. Poso and Poso Creek, Kern County — Price $1.00, sales tax $0.03	1.03
Map No. 35—Round Mountain, Kern County — Price $1.00, sales tax $0.03	1.03

OIL FIELD MAPS—Continued

The maps are revised from time to time as development work advances and ownerships change.

Map	Price (including postage and sales tax)
Map No. 36—Kettleman Hills, Fresno, Kings and Kern Counties---------- Price $1.50, sales tax $0.05	$1.55
Map No. 37—Montebello, Los Angeles County-Price $1.00, sales tax $0.03	1.03
Map No. 38—Whittier, Los Angeles County---Price $1.25, sales tax $0.04	1.29
Map No. 39—West Coyote, Los Angeles and Orange Counties------------ Price $1.25, sales tax $0.04	1.29
Map No. 40—Elwood, Santa Barbara County, and La Goleta, Santa Barbara County ------------Price $1.25, sales tax $0.04	1.29
Map No. 41—Potrero, Los Angeles County----Price $1.00, sales tax $0.03	1.03
Map No. 42—Playa del Rey, Los Angeles County------------------------ Price $1.50, sales tax $0.05	1.55
Map No. 43—Capitan, Santa Barbara County-Price $1.00, sales tax $0.03	1.03
Map No. 44—Mesa, Santa Barbara County---Price $1.50, sales tax $0.05	1.55
Map No. 46—Richfield, Orange County------Price $1.25, sales tax $0.04	1.29
Map No. 48—Mountain View and Edison, Kern County----------------- Price $1.25, sales tax $0.04	1.29
Map No. 49—Fruitvale, Kern County--------Price $1.00, sales tax $0.03	1.03
Map No. 50—Wilmington, Los Angeles CountyPrice $1.25, sales tax $0.04	1.29
Map No. 51—Santa Maria Valley, Santa Barbara County--------------- Price $1.00, sales tax $0.03	1.03
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Map No. 55—Canal, Canfield Ranch, Coles Levee, Strand, and Ten Section, Kern County--------Price $1.25, sales tax $0.04	1.29
Map No. 56—Paloma, Kern County---------Price $1.25, sales tax $0.04	1.29

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STATE OF CALIFORNIA
DEPARTMENT OF NATURAL RESOURCES
RICHARD SACHSE, Director

DIVISION OF MINES
FERRY BUILDING, SAN FRANCISCO

WALTER W. BRADLEY — State Mineralogist

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QUARTERLY CHAPTER

OF

STATE MINERALOGIST'S REPORT XXXVI

STATE DIVISION OF MINES
FERRY BUILDING, SAN FRANCISCO
CALIFORNIA

93872

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State Mineralogist

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Mining Division Boundaries.
Mining Division Offices.

PREFACE

The Division of Mines (formerly State Mining Bureau) is maintained for the purpose of assisting in all possible ways in the development of California's mineral resources.

As one means of offering tangible service to the mining public, the State Mineralogist for many years has issued an annual or a biennial report reviewing in detail the mines and mineral deposits of the various counties.

As a progressive step in advancing the interests of the mineral industry, and as permitting earlier distribution to the public, publication of the Annual Report of the State Mineralogist in the form of monthly chapters was begun in January, 1922, and continued until March, 1923. Owing to a lack of funds for printing this was changed to a quarterly publication, beginning in September, 1923. For the same reason, beginning with the January, 1924, issue, it became necessary to charge a subscription price. This covers approximately the cost of printing.

Pages are numbered consecutively throughout the year and an index to the complete report is included annually in the closing number.

Beginning with the 1930 issues, the activities and progress of the Geologic Branch are recorded also in these quarterly chapters. The important part that geology plays in the economic development of our mineral resources is further recognized in the change of title from *Mining in California* to California Journal of Mines and Geology, beginning with the January, 1933, chapter.

While current activities of all descriptions are covered in these chapters, the practice of issuing from time to time technical reports on special subjects will be continued as well. A list of such reports now available is appended hereto, and the names of new bulletins will be added in the future as they are completed.

The chapters are subject to revision, correction and improvement. Constructive suggestions from the mining public will be gladly received, and are invited.

The one aim of the Division of Mines is to increase its usefulness and to stimulate the intelligent development of the wonderful, latent resources of the State of California.

Types of Reports

In general the reports presented in these chapters are grouped into three classes:

1. Mines and mineral resources of a given county or area (describing kind, character, distribution and extent of development).

2. Specific economic and industrial mineral products (listing and describing the resources over the entire state of a given mineral substance, e.g., feldspar).

3. Geological reports on specific areas (recording results and conclusions with maps, derived from field studies; and tied in with economic possibilities and developments).

REPORTS OF DISTRICT MINING ENGINEERS

In 1919–1920 the Mining Bureau was organized into four main geographic divisions, with the field work delegated to a mining engineer in each district, working out from field offices that were established in Redding, Auburn, San Francisco and Los Angeles, respectively. This move brought the office into closer personal contact with operators, and it has many advantages over former methods of conducting field work, including lower traveling-expense bills for the Bureau's engineers. In 1923 the Redding and Auburn field offices were consolidated and moved to Sacramento.

The Redding office was reestablished in 1928, and the boundaries of each district adjusted. The counties now included in each of the four divisions and the location of the branch offices are shown on the accompanying outline map of the state. (Frontispiece.)

Reports of mining activities and development in each district, prepared by the District Engineer, will continue to appear under the proper field division heading.

REDDING FIELD DISTRICT

Chas. Volney Averill, Mining Engineer

There is no report from the Redding Feld District on account of unfinished field work.

SACRAMENTO FIELD DISTRICT

C. A. Logan, Mining Engineer

On account of unfinished field work, there is no report from the Sacramento Field District in this issue.

SAN FRANCISCO FIELD DISTRICT

C. McK. Laizure, Mining Engineer

Reports covering the mines and mineral resources of all of the counties in the San Francisco Field District are now available, and field work at present is confined to investigations for special reports upon various economic minerals.

LOS ANGELES FIELD DISTRICT

MINERAL RESOURCES OF THE KERNVILLE QUADRANGLE

By W. B. TUCKER, District Mining Engineer, and
R. J. SAMPSON, Assistant District Mining Engineer

The Kernville quadrangle embraces the southeastern corner of Tulare and a portion of northeastern Kern counties. It lies between latitude 35° 30′ and 36° 00′; longitude 118° 00′ and 118° 30′, it contains the southern half of T. 22 S., all of townships 23, 24, 25, 26 and 27 S. and the two north sections of township 28 S., the east sections of range 32 E., all of ranges 33, 34, 35 and 36 E. and the west one-half of range 37 E., Mount Diablo Base and Meridian.

This area is covered by the southern extremity of the Sierra Nevada and elevations range from 2500 ft. at Bodfish, on the Kern River, to nearly 10,000 ft. at the tops of peaks on either side of Little Trout Creek, near the northern line of the quadrangle.

The Kern River, flowing south the full length of the quadrangle at its western boundary, is fed by numerous creeks from the high mountains. The South Fork of the Kern River flows westerly through the central portion of this area.

The climate is mild although the higher mountains receive a considerable snowfall in winter.

The area is readily accessible by paved road up the Kern River from Bakersfield as well as through Walker's Pass from the Owens Valley Highway and through the Tehachapi Pass from Mojave.

MINERAL RESOURCES

The minerals which have been produced commercially in this quadrangle are: Antimony, copper, gold, lead, silver, tungsten and zinc. Gold, the most important of these, is also the most widely distributed.

ANTIMONY

There has been a small production of antimony ore from the quadrangle, largely during the World War. There has been no activity since that time.

Rayo Mine, consisting of 40 acres, is in Sec. 36, T. 26 S., R. 33 E., M.D.M., about 6 miles southeast of Isabella. Present owner is unknown. It is reported that the vein from 3 ft. to 10 ft. wide, has been prospected by open cuts and shallow shafts. Idle.

Bibl.: State Mineralogist's Reports XIV, p. 476; XXV, p. 21.

Tom Moore Mine, comprising 10 acres of patented land, is in Sec. 24, T. 27 S., R. 33 E., M.D.M., on a ridge east of Erskine Creek, about 8 miles southeast of Isabella; elevation 4000 ft.; owner, *Kern Development Co.*, Kernville, Calif.

The vein, about 3 ft. wide, strikes N.-S.; dip 50° E. between granitic walls. It has been developed by open cuts and several shafts from 40 ft. to 65 ft. deep. The property has been idle for many years.

Bibl.: State Mineralogist's Reports XIV, p. 476; XXV, p. 22.

COPPER

So far as is known there is only one copper deposit in the quadrangle, and is described below.

Silverado Copper Group, composed of 3 claims, is on the east side of Erskine Creek, 4½ miles south of Isabella; elevation approximately 5000 ft.; owner, J. L. Hooper, Hobo Hot Springs.

A granitic dike from 200 ft. to 300 ft. wide between schist and limestone is said to carry up to 5% to 6% copper and to average 1½%. The ore mineral is chalcopyrite. This material also is reported to carry 1 oz. silver and .03 oz. to .04 oz. of gold.

The property has been prospected by a 40-ft. shaft, short tunnels and open cuts. Idle except for assessment work.

GOLD

Gold is the most widely distributed and by far the most important metal in point of production in this area.

The Big Blue and Sumner Mine just north of Kernville, discovered in the 70's, has produced intermittently since that time. In the past four or five years it has gradually been rising in prominence again, until now it is one of the principal producers of the county. Next in importance to the Big Blue is the Bright Star, high up in the Piute Mountains. This property has had no production for several years but in the past was a notable contributor.

Beauregard Mine, adjoining the Big Blue on the west, is in Sec. 28, T. 25 S., R. 33 E., M.D.M., about one mile north of Kernville; elevation 2860 ft.; owner, *Kern Development Co.,* Kernville, Calif.

The Beauregard vein is in the hanging-wall granite of the Big Blue-Sumner vein. It forms a junction with this vein on the Sumner North Extension Claim just east of the Beauregard end line. The Beauregard vein strikes N. 75° E., dips 85° NW. and has an average width of 4 ft. The pay shoot worked is reported to be 600 ft. in length, averaging 3 ft. in width. The ore is said to plate $20 to $35 per ton, with concentrates carrying $150 per ton.

The mine is developed by a shaft 300 ft. deep, with levels at 100, 200 and 300 ft. On the 200-ft. level a drift on the vein was driven northeast 650 ft. At this point the vein was cut off by a north-south fault. A drift was driven 200 ft. north on the fault. A crosscut was driven east 200 ft. in the slate footwall to the Big Blue-Sumner vein on the adjoining claim. There is a total of some 2500 ft. of drifts on these three levels.

The Beauregard is now a part of the Big Blue Mine, the operation of which is described elsewhere herein.

Bibl.: State Mineralogist's Reports XIV, pp. 487-488; XX, pp. 36-40; XXV, pp. 42-43; XXIX, p. 289.

Beauregard Extension Mine, comprising 2 claims, is in the Cove Mining District, adjoining the Big Blue Mine on the west, about 2 miles northwest of Kernville; elevation 3000 ft.; under lease to D. A. Boyd, Kernville, Calif.

The country rock is granite. The two parallel quartz veins about one hundred feet apart, strike N. 50° E. and dip 75° to 80° SE. Width is from 2 ft. to 4 ft. Ore is free-milling, with some sulphides. Ore shoot varies from 80 ft. to 160 ft. in length.

Development consists of 300-ft. shaft on the Beauregard vein, with levels at the 80, 160, 200 and 240-ft. horizons. At the 80-ft. level, a tunnel has been driven 100 ft. northeast to the shaft. On the 160-ft. level drift 100 ft. northeast; on 200-ft. level drift 50 ft. southeast; on 240-ft. level drift 160 ft. southwest and 190 ft. northeast.

Mine equipment consists of 2-drill compressor and 25-h.p. single drum hoist.

Mill consists of 6 in. by 8 in. jaw crusher; two 10-stamp Straub mills, plates and an Economy table. Idle.

Big Blue and Sumner Mine, comprising 8 claims, is on the west side of the Kern River, about one mile north of Kernville, in Sec. 28,

Outcrop and Glory Hole on Big Blue-Sumner Mines, Cove District, Kernville

T. 25 S., R. 33 E.; elevation 2900 ft.; owner, *Kern Development Co.,* C. S. Long, president, Kernville, Calif.; under lease and bond to Big Blue Mines, Inc., Roland Toggnazzini, president; Walter Bates, secretary, 605 Market St., San Francisco; John W. Prout, consulting engineer, 548 S. Spring St., Los Angeles.

A full description of this property by Mr. Prout is included herewith (see p. 379.)

Bibl.: State Mineralogist's Reports VIII, p. 313; XIV, pp. 488-489; XXV, pp. 27-28; XXIX, pp. 289-291; XXXVI, p. 28.

Bright Star Mine, comprising 3 patented claims, is in the Green Mountain District in Sec. 7, T. 28 S., R. 34 E., M.D.M., 11 miles south and 5 miles east of Isabella; elevation 7500 ft.; owner, Miss Ann Lacy, 2662 Union St., San Francisco, Calif.; under lease to T. P. Lane, Weldon, Calif.

The quartz vein in slate strikes NE.; dip 60° N. Average width is 20 in. Mineralization consists of free gold and auriferous pyrite. Ore shoot worked was 120 ft. long by 20 in. wide. The ore was high grade.

Development consists of a shaft on the vein 540 ft., with three levels. There is said to be several thousand feet of drifts, raises and stopes. Mine was shut down and full of water at time of visit. Production is said to have been $600,000. The tailings from the original mill were successfully treated by cyanidation in the early part of the twentieth century. Idle.

Bibl.: State Mineralogist's Reports XII, p. 142; XIII, p. 187; XIV, p. 490; XXV, p. 30.

Brown Dyke Mine, consisting of 5 claims, is situated at the head of Gold Canyon about one mile northwest of Fairview and 16 miles north of Kernville, in Sec. 14, T. 23 S., R. 32 E., M.D.M.; elevation, 4500 ft.; owner, F. Albert Morrison, Fairview, Calif.

The formation is quartzite which stands practically vertical. There is a series of fault fractures or planes which strike N. 30° E.; dip vertical. Adjacent to these planes of movement, the quartzite is fractured and mineralized with fine-grained pyrite and some free gold. The minor fractures are at an angle of about 30° with the principal slips and stop abruptly at these planes. Two of these major slips, about 20 ft. apart, have been found in the crosscut and since the mineralization occurs on both sides of one of them it is probable that the walls of any orebody encountered will have to be determined by assay. Assays of samples taken from the present workings do not show uniform values, varying from $2 to $30 or more in spots. The mineralization in the crosscut has been shown to have a width of 25 ft. or more and it is possible that it extends still farther to the north.

Development consists of a 50-ft. shaft, on 25-ft. level drift 12 ft. southeast and 30 ft. northwest; on 50-ft. level 25 ft. of drifts. About 180 ft. south and 130 ft. below the collar of this shaft, a crosscut has been driven north 160 ft. At 140 ft. the first slip mentioned above was encountered and a drift driven east 40 ft. At 160 ft. the second slip was found and a drift driven east 75 ft. This last drift is almost vertically under the shaft. Two men are working driving the drift by hand.

Commonwealth Mine, comprising 32.4 acres of patented ground, is in Sec. 15, T. 25 S., R. 33 E., M.D.M., on the west side of the Kern River, about 3 miles north of Kernville; elevation 3000 ft.; owner, *Kern Development Co.,* C. S. Long, president, Kernville, Calif.

Four parallel veins occur in the granitic country rock, reported to average 4 ft. in width. They have been prospected by shallow shafts and open cuts.

Bibl.: State Mineralogist's Report XVI, p. 491.

Dead River Placer of 40 acres, is in Sec. 17, T. 26 S., R. 33 E., M.D.M., one-half mile north of Isabella; owner, Charles Gibson, Isabella, Calif.

This is a channel which was worked in 1890 by Steve Barton, of Isabella. It is about 300 ft. wide, 6 ft. to 8 ft. deep to a granite bedrock. It occurs along a small tributary to the Kern River which runs east and west. Pay gravel is said to average 50 cents per yard. Idle.

Drunkard's Dream Mine, consisting of 11 claims, is in the Clear Creek Mining District, on the ridge between Clear Creek and Haight Canyon, in Sec. 17 and 18, T. 28 S., R. 33 E., M.D.M., 4 miles east of Havilah; elevation 7000 ft.; owners, Jessie L. Stubblefield, E. A. Rosa and Earl E. Lambert, Havilah, Calif.

Two parallel veins in the granite, about 30 ft. apart on the surface, strike N. 70° W. One of these dips about 45° NW., the other 65° NW. They form a junction some 50 ft. below the surface. They vary in width from 2 ft. to 4 ft. Vein matter consists of ground-up quartz and altered wall rock. The gold is free. At the tunnel level, about 100 ft. below the surface, the 65°-dipping vein apparently has been faulted. The strike of the fault is approximately parallel to the vein, with a dip of 63° SE. The width between walls is up to 16 ft. or 18 ft. This space is filled with broken up and altered country rock and clay. It is reported that some broken-up ore is found in this material. This would indicate that prospecting for the faulted section should be done to the north of the outcrop, both on the surface and by crosscutting from the tunnel level. The ore shoot formed by the junction of the two veins has been stoped for a length of 160 ft. This stope started about 35 ft. above the tunnel and was carried up to the surface. The ore was from 2 ft. to 4 ft. wide and averaged better than $30 per ton.

Development consists of a crosscut tunnel driven N. 40° W. 170 ft. to the vein and a drift west on the vein 375 ft. A winze was started on the footwall of the fault and was 12 ft. deep at the time of visit (July 14, 1935). There is a 25-ft. shaft on the vein above the tunnel and open cuts and shallow shafts have exposed the vein on the surface for a distance of about 1000 ft.

Near the portal of the tunnel the following mill was erected: 7 in. by 10 in. Dodge crusher, 75-ton crushed ore bin, Challenge feeder to 3½-ft. Huntington mill, 4 ft. by 8 ft. plate; tailings to settling pond. Power is supplied by 15-h.p. gas engine; capacity 10 tons. Idle.

Bibl.: State Mineralogist's Report XXIX, p. 298.

Fairview Group of 3 claims is situated west of Kern River, in Sec. 11, T. 23 S., R. 32 E., some 17 miles north of Kernville, in Tulare Co.; elevation about 3900 ft.; owner, J. L. Sweet, Fairview, Calif.

On these claims, a quartz vein, strike E.-W., in the metamorphic series composed of quartzite, crystalline limestone and schist, has been prospected by a series of shallow shafts and open cuts. The vein is some 5 ft. to 6 ft. in width and is filled largely with quartzite, carrying pyrite.

Idle except for assessment work.

Glen Olive Mine, consisting of 6 claims, is in the Piute Mountains, in Sec. 33, T. 27 S., R. 33 E., M.D.M., about $8\frac{1}{2}$ miles south of Isabella, at the head of Bodfish Creek; elevation 7500 ft.; owners, A. W. Stetson and associates, of San Francisco; leased to C. A. Burns, Bodfish, Calif.

There are two parallel veins about 200 ft. apart; width 3 ft.; strike NW.-SE. Developed by two tunnels about 200 ft. apart, with several hundred feet of drifts and raises; also three winzes each about 100 ft. deep. The ore shoot was about 200 ft. long and was stoped between tunnels. Ore is free milling and said to have yielded $25 per ton.

Present operator, working alone, is milling ore in a 3-stamp mill.

Bibl.: State Mineralogist's Reports XIV, p. 494; XXV, p. 34.

Gold Standard Mine, comprising 3 claims, is in Sec. 12, T. 28 S., R. 33 E., M.D.M., about 5 miles east of the Bright Star Mine; elevation about 5800 ft.; owners, J. E. Moreland and Mrs. J. H. Potter Estate, 442 South G St., Porterville, Calif.

Two parallel veins about 100 ft. apart cut the slate country rock; strike N. 70° E.; dip 50° SE. Width is 8 in. to 2 ft., average about 12 in. The ore is said to run from $40 to $400 per ton.

Development consists of tunnel driven northeast 150 ft., with a 30-ft. winze at 100 ft. from the portal. An ore shoot above this winze is 40 ft. long, about 18 in. wide and is said to average $70 per ton. There is a 30-ft. tunnel on the other vein which is 100 ft. south of the main workings.

Mine equipment consists of 110-cu. ft. compressor, driven by a gas engine. A 500-ft. enclined tramway operated by 6-h.p. gas hoist, is used for transporting supplies from the camp to the tunnel. Idle.

Iconoclast Mine is on Erskine Creek, in Sec. 25, T. 27 S., R. 33 E., M.D.M., 8 miles southeast of Bodfish. Holdings consist of 40 acres, patented; elevation about 4800 ft.; owner, Coulston Estate, Pasadena, Calif.

The quartz vein, 6 in. to 4 ft. wide, has a schist hanging wall and granitic footwall. It has been developed by two tunnels, the upper being 250 ft. in length, the lower tunnel 60 ft. below, has been driven 525 ft. At about 250 ft. from the portal of lower tunnel, a winze has been sunk to approximately 50 ft. in depth. An ore shoot above this winze was stoped between tunnels for a length of 50 ft. Some 400 tons were milled. The ore is said to have averaged about $15 per ton, largely in silver.

There is an assay office on the property and the following described mill: Jaw crusher, 3 ft. by 6 ft. ball mill, Dorr type Simplex classifier, 6-ft. air flotation cell and Economy table. Power is supplied by a gas engine. Capacity is approximately 25 tons.

In addition to ore milled on the property, it is said that several shipments were made to Hooper's mill at Hobo Hot Springs. Idle, shut down in August, 1939.

Bibl.: State Mineralogist's Reports XIII, p. 186; XIV, p. 497; XXV, p. 36.

Illinois & Golden Belt Mine, comprising 60 acres in the Pioneer District, on the southwest side of Erskine Creek, is in Sec. 16, T. 27 S., R. 33 E., M.D.M., some $3\frac{1}{2}$ miles southeast of Bodfish; elevation 7800 ft.; owner, J. Peep, Bodfish, Calif.

A quartz vein 12 in. wide, having a slate footwall and granite hanging wall, has been developed by a 300-ft. tunnel. The ore which is free milling, occurs in pockets in the vein. It is said to have produced $12,000. Idle.

Bibl.: State Mineralogist's Reports XIV, p. 497; XXV, p. 36.

Jeannette-Grant Mining Co. has 16 claims in the Green Mountain District, surrounding the Bright Star Mine. These claims are largely in Sec. 4 and 10, T. 28 S., R. 34 E., about 12 miles southeast of Isabella; elevation about 6800 ft.; owner, Jeannette-Grant Mining Co., N. C. Anderson, 22102 Clovella St., Canoga Park, Calif.

About three-quarters of a mile northeast from Bright Star shaft and several hundred feet below, this company has driven a crosscut 800 ft. in the expectation of encountering a vein supposed to be the extension of the Bright Star which is reported to outcrop on the hill several hundred feet above the crosscut. The operators believe that they have only 50 ft. or 60 ft. farther to go. Driving of the crosscut has been suspended and they are now hauling old tailings from the Yellow Boy Mine which was just south of the Bright Star. These tailings are being treated in five sand tanks which have been erected near the portal of the crosscut mentioned above. Four men are working.

The Yellow Boy, adjoining the Bright Star on the south, has been leased to I. J. Schaub, who is cleaning out an old shaft reportedly 80 ft. deep. He is now down some 30 ft.

Josephine Group of 3 claims, is in the Clear Creek Mining District, in Sec. 34, T. 27 S., R. 33 E., 8 miles southeast of Bodfish; elevation 7000 ft.; owners, Miss Josephine Sefton and Tom Smith, 725 Amalfi Drive, Santa Monica, Calif.

A quartz vein 12 in. to 2 ft. wide strikes NE.-SW., dips 40° SE. It carries free gold.

Development consists of 60-ft. tunnel on the vein on Josephine No. 1 Claim. Here the vein is 12 in. and shows free gold. On Josephine No. 2, there is a 50-ft. shaft and on Josephine No. 3 there are two 50-ft. shafts. All are on the vein.

At present they are erecting a small mill near the Bodfish-Piute road. Four men are working.

King Solomon Mine, composed of 2 claims, is in Sec. 9 and 10, T. 28 S., R. 33 E., M.D.M., in Clear Creek Mining District, 4 miles east of Havilah; elevation about 6000 ft.; owner, J. L. Stubblefield and E. A. Rosa, Havilah, Calif.

The vein, 3 ft. wide, occurs between granite walls; strike NE.-SW.; dip 60° S. Mineralization consists of free gold, pyrite and arsenopyrite.

Old workings now caved, consist of a tunnel driven northeast 2800 ft. connecting with 300-ft. shaft. It is reported that the pay shoot, 300 ft. long, was stoped to the surface from this tunnel. Later

workings consist of a number of shallow shafts, 50 to 70 ft. sunk on stringers in the granite to the north of the old workings.

There is an old 5-stamp mill on the property. Idle.

Bibl.: State Mineralogist's Reports XIV, p. 500; XXIX, pp. 312-313.

Lady Belle & Bull Run Mines, consisting of the Bull Run, Boston Belle, Jeff Davis and Lady Belle claims, are now parts of the Big Blue Mine. They are in Sec. 28, T. 25 S., R. 33 E., M.D.M., in the Cove District, about one mile north of Kernville; elevation 2980 ft.; owner, Lady Belle Mining Co., C. S. Long, president, Kernville, Calif.; under lease and Bond to Big Blue Mines, Inc., Roland Toggnazzini, president; Walter Bates, secretary, 605 Market St., San Francisco.

The Lady Belle-Bull Run vein occurs in the hanging wall granite of the Big Blue-Sumner vein with which it forms a junction on the Sumner Claim east of the Bull Run end line. Its strike is N. 75° E., dip 62° N.; average width 3 ft.

Development consists of a 380-ft. shaft sunk on the vein on the Lady Belle Claim. Four levels were driven from this shaft with drifts aggregating several thousand feet. The ore shoot stoped was 250 ft. long by 3 ft. wide.

On the Bull Run Claim there is an incline shaft 360 ft. deep, seven levels, several thousand feet of drifts and crosscuts and one stope 900 ft. in length.

On the Jeff Davis Claim which parallels and adjoins the Bull Run on the south, there is a 12-in. vein in the granite. It has been opened by a shaft 200 ft. deep.

Bibl.: State Mineralogist's Reports XIV, pp. 490, 498 and 501; XX, pp. 40-41; XXV, p. 30.

Laurel Mine, consisting of 6 claims, known as Marble No. 1, 2 and 3 and Perth Amboy No. 1, 2 and 3, is in Sec. 26, T. 27 S., R. 33 E., M.D.M., on a ridge west of Erskine Creek, in Valley View Mining District, 14 miles southeast of Isabella; elevation 5000 ft.; owner, *Erskine Mining Corp.,* Walter A. Sheek, president, 2128 Lime Ave., Long Beach, Calif.

The formations are quartz-monzonite, crystalline limestone and schist. The limestone lies between the granite rock and the schist. The contact strikes N. 17° W. and dips 80° NE. The ore occurs in a fracture along the contact of the limestone and schist as a replacement of the limestone. It is from 6 ft. to 12 ft. wide. Mineralization consists of pyrite, chalcopyrite and sphalerite. The ore shoot has been exposed for a length of 80 ft. without having reached the end of it. The ore is said to carry about $7 in gold and $5 in silver and copper. It is also said to carry 1½ oz. of indium but this metal has not been produced commercially.

Development consists of an upper tunnel driven southeast 70 ft. with a 45-ft. shaft. The lower tunnel is 96 ft., vertically below upper tunnel. It has been driven east 125 ft. where it branches northeast and southeast 70 ft. to the limestone schist contact. At the point where the southern branch reached the contact, a raise was put up 80 ft. to connect with 45-ft. shaft. At the end of the northern branch,

a 70-ft. raise has been driven. From the end of each branch, a crosscut has been driven easterly 130 ft. in the limestone. These crosscuts were to be continued to the monzonite-limestone contact.

Mine equipment consists of 300-cu-ft. air compressor. The following mill was erected on the property: 9 in. by 16 in. jaw crusher, belt feeder, 4 ft. by 4 ft. Marcy type ball mill, Dorr type Simplex classifier, 5 Hughes flotation cells. Machines had individual motor drives. Power was supplied by diesel engine, belt connected to generator. Engine has been removed.

Water was obtained from a spring through 3000 ft. of 2-in. and 3-in. pipe line.

Bibl.: State Mineralogist's Report XXIX, pp. 314-315.

Little Bonanza Mine, comprising one claim, is in Sec. 25, T. 26 S., R. 32 E., M.D.M., about 2 miles southwest of Isabella; elevation about 3000 ft.; owner, A. R. Lucy, Isabella, Calif.

A narrow quartz vein in the granite has been prospected by a 140-ft. tunnel. Idle.

Bibl.: State Mineralogist's Reports XII, p. 191; XIV, p. 501; XXV, p. 39.

Million Stamp Mine includes 10 claims and 2 fractions in Sec. 11, T. 23 S., R. 32 E., M.D.M., on the west side of the Kern River, 1½ miles north of Fairview and about 17 miles north of Kernville; owner, Richard Weed and J. C. Howe, Road's End Post Office, Tulare Co., Calif.

The country rock consists of ribs of quartzite, limestone and schist. These ribs which stand at high angles, strike about N. 75° W. The schist, forming the southern flank, is probably 500 ft. or more in thickness, and contacts the limestone which is some 150 ft. thick. This limestone is either faulted or is a lenticular mass whose eastern end is just west of the main tunnel described below. To the north of the limestone is quartzite, several hundred feet in thickness.

A crosscut tunnel has been driven north 500 ft. in the schist and a 50-ft. winze on a 45° inclination to the north. Forty feet above this tunnel, a tunnel has been driven north 100 ft. with a 45-ft. winze at face which connects with lower tunnel at 50-ft. winze mentioned above. In general assays of samples from these workings are very low grade but assays in the winze vary from about $6 to $23.

A mill was built at the portal of the main tunnel. The building still stands but all of the equipment has been removed. Idle except for assessment work.

North Star Group, comprising 5 claims, adjoins the Bright Star on the east. It is in Sec. 10 and 11, T. 28 S., R. 34 E., 12 miles southeast of Isabella; elevation about 7500 ft.; owner, Mrs. Mattie Moreland, on the ground.

The quartz veins in quartzite schist, strike N. 45° E., dip 55° SE. There are at least four of these veins, roughly parallel and from 500 ft. to 600 ft. apart. Leases have been let on three of them.

The principal development work consists of 110-ft. shaft on the vein. On the 100-ft. level drifts have been driven 50 ft. northeast and 115 ft. southwest. There is a stope 25 ft. long, 40 ft. high, 18 in.

to 3 ft. wide above the northeast drift; also small, underhand stope below this level.

The ore is hauled to the 2-stamp mill at the Little Joe Mine some 6 miles southeast. The ore is said to carry $60 to $65 per ton in gold.

Equipment consists of one drill compressor and 6-h.p. gasoline hoist. Four men are working.

Six hundred feet east of the above workings, on the adjoining claim, Gaines Marson and M. C. Evans have a lease on a parallel vein. They have sunk on the vein 45 ft. and are starting a drift southwest. The vein in these workings is up to 8 in. in width.

Equipment consists of one drill compressor and gasoline hoist. Two men are working.

On the adjoining claim to the east of the Marson lease, G. C. Deakins and W. L. Sears have sunk a shaft 100 ft. on a parallel vein which is from 2 in. to 40 in. wide. Equipment consists of one drill compressor and gasoline hoist.

Two miles south of their lease they erected a 10-ton bin, grizzly and a small, Huntington type mill, about 3 tons capacity. To date, have milled about 15 tons which contained very little value. Two men are working.

H. E. Cook has a lease on the Evening Star Claim which adjoins the North Star on the west. They have sunk 50 ft. on a vein which is up to 2 ft. in width. On the 50-ft. level have drifted 70 ft. southwest. Two men are working.

Silver Crown Group of 5 claims is situated on a ridge north of Pack Saddle Canyon, in Sec. 7, T. 23 S., R. 33 E., M.D.M., 2½ miles northeast of Fairview, about 17 miles north of Kernville; elevation 5000 ft.; owner, Wm. Andrews, Roads End Post Office, Tulare Co., Calif.

The country rocks are limestone and schist. Contact strikes N. 15° W.; dip 70° E. A tunnel has been driven N. 10° W. 220 ft. in the schist. Forty feet above these workings, a tunnel has been driven north 110 ft. The first 100 ft. is in limestone. The face is in the schist. Face assays $2.20 per ton.

On Silver Crown No. 2 Claim, there is a fissure in the limestone about 20 ft. wide; strike N. 20° W.; dip 75° E. Filling is heavily iron-stained. Mineralization consists of hematite, lead and zinc carbonates.

Idle except for assessment work.

TUNGSTEN

While there have been many prospects containing scheelite in this area, there has been but little production.

Recent developments and the erection of a mill at Weldon would seem to indicate increased activity which may result in considerable production of this useful war metal.

Fairfield Mining & Milling Co., Allan C. Sutton, president; Geo. Smith, general manager, Weldon, Calif., has taken leases and options on four tungsten properties in the quadrangle, to-wit, the Tungsten King, Prosperity, The Lode and Miranda. These properties are described herein under the various names.

The company has erected a mill at Weldon for the treatment of ore from these properties and will also do custom milling. The mill is built on a hillside just above the town of Weldon.

From coarse-ore bin, material is fed to Comet gyratory crusher, to boot of elevator to vibrating screen; oversize to Straub balanced crusher, product to above-mentioned elevator; screenings to crushed-ore bin, belt conveyor feeder to vibrating screen and 2 jigs, to 2 Diester roughers and one cleaner table. All machines have individual motor drives.

Water is obtained from a well in Weldon. Power is supplied by Southern California Edison Co. Six men are working on construction.

Little Dick Tungsten Mine comprises 5 claims, situated on ridge east of Kern River, 3 miles northeast of Kernville, in Sec. 23, T. 25 S., R. 33 E.; elevation about 3700 ft.; owner, C. W. Pascoe, Kernville, Calif.; was under lease to C. J. Gusty, Kernville, Calif.

The deposit occurs in a roof pendant of metamorphic rocks (altered sediments) on the top of a knoll. It is in a hard, crystalline limestone which is underlain and surrounded by diorite. The contact metamorphic material is composed of garnet, epidote, some quartz and calcite, with minor hornblende and comparatively larger particles of scheelite. It is lenticular, its greatest width being about 25 ft. There is little hope for any depth as it is cut off by the diorite. The ore is said to carry 1½% WO_3.

Development consists of open cuts and short drifts on the various lenses.

Mill on the property consists of jaw crusher, small ball mill and table. Capacity is about 10 tons. Idle.

The Lode Tungsten property embraces 7 claims, situated about 1½ miles south of Weldon, in Sec. 11, T. 26 S., R. 34 E., M.D.M.; elevation about 3100 ft.; owners, Mrs. Alice Cochran, Isabella, Calif., and -------- Winter et al, Bakersfield, Calif.; under lease and option to Fairfield Mining & Milling Co.

The country rock is granitic with included remnants of crystalline limestone. The deposit which is composed of contact metamorphic minerals appears to be wholly in the granitic rocks. Its strike is E.-W., dip 70° S., width about 5 ft. Mineralization consists of hornblende, epidote, garnet and a small amount of quartz and scheelite.

Development consists of two shafts 80 ft. and 30 ft. deep, sunk on the "vein." They are about 250 ft. apart. The 80-ft. shaft is east of the 30-ft. shaft. The mineralization in these shafts shows a rather consistent width of about 5 ft. While both walls are granitic, the hanging wall is a somewhat finer-grained phase than the footwall.

The property is subleased to J. M. Collins who will ship to the Weldon mill when it is completed.

Miranda Group of 4 claims is 6 miles west of Weldon and 3 miles north of the Weldon-Isabella road in Sec. 1, T. 26 S., R. 33 E., M.D.M.; elevation about 3100 ft.; owner, Theodore Miranda, Isabella, Calif.; under lease and option to *Fairfield Mining & Milling Co.*

A band of crystalline limestone, some 30 ft. thick, standing vertically in the granitic country rock, outcrops on its N. 70° W. strike for a distance of about 200 ft. Its dip is 60° NE. At the northwest

end of this outcrop, the limestone disappears but is visible on the top of a knoll about 800 ft. distant. At the southeast end it is faulted along a north-south line with a displacement of some 150 ft. to the south where the last remnant, some 20 ft. thick and 40 ft. long, is visible.

Along the contact of the limestone and granite, small lenses of contact metamorphic minerals occur. The deposits consist of garnet, lime feldspar, calcite, a little quartz and epidote, together with about 1% WO_3 in scheelite.

Development consists of some small open cuts and a 30-ft. shaft sunk on the contact. At this point the ore is about 6 ft. wide. Two men are working.

Prosperity Tungsten Claim is in Sec. 35, T. 27 S., R. 32 E., M.D.M., about 1¼ miles north of Havilah and 1¼ miles south of Tungsten King; elevation about 3000 ft.; owner, A. O. Zuck and W. R. Tillman, Havilah via Caliente, Calif.; under lease to *Fairfield Mining & Milling Co.*

The quartz vein in granite strikes N. 10° E.; dip 80° E. The quartz is only slightly iron-stained, carries a small percentage of pyrite and about 1% WO_3 in scheelite.

Development consists of open cuts and a crosscut tunnel west 35 ft. to the vein which is 14 ft. wide at this point and a drift south 15 ft.

From a bin at the portal of the crosscut, a steel-lined, wooden chute 180 ft. long conveys the ore to bin at the road below.

Of a total of 9 men working here, 6 are subleasers.

Syrus Canyon Tungsten Group, comprising 6 claims, is 2 miles east of Kernville, in Sec. 35, T. 25 S., R. 33 E.; elevation 3000 ft.; owner, C. W. Pascoe, Fairview, Calif.

The quartz outcrops on these claims, carrying scheelite. There has been nothing but assessment work done. Idle.

Tungsten King Mine, comprising one claim, is 2½ miles north of Havilah and one-quarter of a mile north of Clear Creek, in Sec. 26, T. 27 S., R. 32 E., M.D.M.; elevation about 3200 ft.; owners, A. O. Zuck and W. R. Tillman, Havilah via Caliente, Calif.; under lease and option to Fairfield Mining & Milling Co.

The country rock is granitic. There is a quartz vein (segregation) in this formation which strikes N. 40° W. A series of parallel cross fractures, N. 10° E., dip 86° E., intersects this vein. Where the cross fractures cut the veins, the quartz carries scheelite in appreciable quantity. Three parallel cross fractures have been cut by a crosscut driven N. 40° W. 150 ft. At the portal there is 6 ft. of quartz in which occurs yellow scheelite crystals. This material carries from 2% to 3% WO_3. The face now shows 5 ft. of the same material and the west extremity has not yet been reached. About 60 ft. above is an open cut made on one of these intersections.

Equipment consists of 320-cu. ft. compressor. A bin has been erected on the hillside with 320 ft. of jig-back tram to a bin at the road below.

Shipments of ore to Weldon will begin when the mill is completed.

Bibl.: State Mineralogist's Reports XVII, pp. 315-316; XXV, p. 62.

GEOLOGIC BRANCH

CURRENT NOTES

By Olaf P. Jenkins, Chief Geologist

In This Issue

Another report on the basic geology of a specific area (in this case the Kernville quadrangle) has been contributed in this issue of the California Journal of Mines and Geology by two members of the faculty of the Department of Geology of the University of California at Los Angeles: Professors William J. Miller, and Robert W. Webb.

The economic mineral resources of this same area are discussed by members of the staff of the Division of Mines, W. B. Tucker and R. J. Sampson, in "Mineral Resources of the Kernville Quadrangle." Of particular importance at this time in connection with this economic inventory, is the notation of the occurrence of certain of our strategic minerals, i.e., *antimony* and *tungsten.*

In addition to these two general reports, one describing the geology and the other the mineral deposists, is a more detailed report on the "Geology of the Big Blue Group of Mines," which also occur in the Kernville quadrangle. This detailed report on mining geology has been contributed by Dr. John W. Prout, Jr.

It is the object of the Geologic Branch to coordinate basic geology with mining, and with the mineral industry in general. These three reports, published under the same cover, should indicate progress in this endeavor.

In the Next Issue

Two papers on strategic minerals (both of them contributions) will appear under Geologic Branch in the next issue of the California Journal of Mines and Geology:

"Strategic Minerals Procurement," by Charles White Merrill; "Geologic Investigation of the Chromite Deposits of California," by John Eliot Allen.

STRATEGIC PROBLEMS OF THE MINERAL INDUSTRY IN CALIFORNIA*

By Olaf P. Jenkins, Chief Geologist

It so happens that in every industry certain minerals control, to a greater or less extent, the development and the very existence of that industry. Without these necessary minerals, the wheels of progress stop.

It so happens that no nation on earth possesses *all* the various minerals needed. In time of peace, to overcome this deficiency, the necessary deficient minerals are imported. In time of war, however, restriction of importation may be so serious to certain industries of a nation as to cripple that nation both from a military standpoint and from a standpoint of internal development.

Present day national defense should not and does not consider military defense alone, but it is studying with great care that possibility (which may turn out to be much the more serious) of economic warfare, should the balance of power become so unbalanced as to leave one power to dominate the earth. This could come about should one power possess all the various minerals needed in all its industries.

It behooves us all, therefore, who are in this work of studying minerals, their origin, development, and their significance to the growth and existence of a nation, to look towards the strategic problems of national defense as in large part the problems of the mineral industry.

For the reason that our nation possesses only minor amounts of certain necessary minerals, much less of consequence is written in this country concerning our deficient strategic minerals (which are of most concern to the nation in time of war), than of our famous commercial mines.

The nation learned a lesson, however, in World War I, when it awoke to the fact that the United States had strategic minerals to consider. During that time (1917–1918) broad surveys were made throughout the United States on strategic minerals. Some of the results were published, some filed, and others were practically forgotten after the armistice was signed. Now the United States Geological Survey and Bureau of Mines are restudying, with greater care, the deposits of strategic minerals which appear to be of most importance. The California State Division of Mines has, as have many mining and geological bureaus in other states, also entered into this problem of making available to the public the desired detailed information regarding these minerals of national defense.

One recent result of this study is ''Economic Mineral Map, No. 1 Quicksilver,'' prepared by the Geologic Branch. Accompanying this

* Paper read before American Institute of Mining and Metallurgical Engineers' affiliated student organizations of Stanford University and University of California, at Berkeley, October 30, 1940.

map is the recent report contributed by Alfred L. Ransome and John L. Kellogg, ''Quicksilver Resources of California.'' Also on hand, in manuscript form is a state-wide report on ''The Tungsten Resources of California,'' by John F. Partridge. In the next issue of the California Journal of Mines and Geology (January 1941) will be published a report by John Eliot Allen on a ''Geological Investigation of the Chromite Deposits of California.'' In the April issue of the Journal will probably be published an economic and metallurgical discussion of the chromite resources of the State by Leonid Bryner.

Most helpful in making possible the studies of these problems of strategic minerals, has been Mr. Charles Dobbel, Professor of Mining at Stanford University, who has guided several graduate students in the study of certain of these minerals of national defense. The studies have been cooperative undertakings with the Geologic Branch. Besides A. L. Ransome, J. L. Kellogg, and Leonid Bryner, are three other Stanford graduate students who are now at work studying other strategic minerals. They are as follows:

J. Gordon Cole, on optical quartz crystal, and antimony.
Robert S. Kroger, on manganese.
Richard J. Segerstrom, on tin.

Now let us see why certain minerals are considered strategic. According to Roush (''Strategic Mineral Supplies,'' 1939) out of a list of 25 mineral products especially important in the development of a war program, 17 are considered in the deficient class, so far as the United States is concerned.

aluminum	asbestos
antimony	fluor spar
chromium	graphite
manganese	iodine
mercury	magnesite
nickel	mica
platinum	potash
tin	pyrite
tungsten	

Two of these, nickel and tin, are practically lacking in the United States.

The United States has been by far the largest producer and largest consumer, and has stood next to Russia in being the most self-sufficient nation in mineral products. But these conditions can not stand as nations combine to form new powers with combined mineral supplies.

At present, according to definition from Federal authorities, the deficient materials of the United States are divided into two classes, Strategic and Critical. Quoting from this authority:

> "Strategic materials are those essential to national defense, for the supply of which in war dependence must be placed in whole, or in substantial part, on sources outside the continental limits of the United States; and for which strict conservation and distribution control measures will be necessary.
>
> "Critical materials are those essential to national defense, the procurement problems of which in war would be less difficult than those of strategic materials either because they have a lesser degree of essentiality or are obtainable in more adequate quantities from domestic sources; and for which some degree of conservation and distribution control will be necessary."

STRATEGIC MATERIALS

antimony	mercury	rubber
chromium	mica	silk
coconut shell char	nickel	tin
manganese, ferrograde	quartz crystal	tungsten
manila fiber	quinine	

CRITICAL MATERIALS

aluminum	iodine	platinum
asbestos	kapok	tanning materials
cork	opium	toluol
graphite	optical glass	vanadium
hides	phenol	wool

There is still a third group of ''essential'' materials, of which the United States has at present apparently adequate domestic supplies but which may some day become ''strategic'' or ''critical''*:

beryllium	cobalt
magnesium	molybdenum
uranium	zirconium
acetone	ethyl alcohol
nitrogen compounds	sulphuric acid
sisal	certain foodstuffs
copper	iron and steel
lead	zinc
abrasives	paper and pulp
petroleum	refractories

and others.

As stated by Charles W. Merrill (''Strategic Minerals of California,'' California Journal of Mines and Geology, July 1938), to supply these deficiencies, four methods may be considered:

1. Maintenance of trade routes.
2. Use of substitutes.
3. Collection of stockpiles.
4. Development of domestic resources.

The first of these methods applies especially to our western hemisphere, not only between United States and Canada, but throughout both North and South America.

In the second method, the chemical industry has helped out the situation, but substitutes are not in general entirely satisfactory.

The third method requires that the government must purchase and store supplies of sufficient quantity to outlast the time the nation is involved in war.

The fourth method has to do with exploration, and to this phase of the subject the particular interest of mining engineers and geologists, should be directed.

There are many other problems, varied and complex, that have to do with an attempt to place the nation in a more favored position as regards deficient minerals:

To reserve the supplies by suspension of production.

To reserve the supplies by restriction of use or by substitutes.

To develop peace time production by development of low grade deposits.

* Bradley, Walter W.: America Needs Our Mineral Wealth. California—Magazine of the Pacific, September 1940, pp. 20, 21, 41.

To build up reserves in the form of jewelry and utensils, the use of which may be diverted in time of war.

To encourage recovery of secondary metals.

Not only has California an interesting and diversified climate, scenery, and surface relief, but this State has also been favored with an exceedingly long list of commercial minerals and rocks. In this list are many of the so-called strategic and critical minerals. In fact some of these minerals have important past records of production, while others await further exploration and development. There are also excellent opportunities for further discovery of deposits hitherto unknown.

Right at this point, geology steps in as a guiding hand. Let us see what are the minerals with which we are to deal, and how they are known to occur in the State.

Quicksilver, chromium, magnesite, manganese, have all been found and produced in the State, and often occur in the same general locality, as in parts of the Coast Ranges. For this reason and for the reason that many of them occur within comparatively short distances from San Francisco, they are in a position subject to danger by sabotage or invasion, and therefore must be protected in time of war.

For the most part, these four minerals where they occur in the Coast Ranges, are found in the Jurassic Franciscan formation. But that does not mean they all were formed at the same time as that formation or through the same agencies that formed it.

Quicksilver is one of the late comers, entering during the Pliocene, Pleistocene, and even Recent periods, along faults of that time and by means of hot-spring waters, which have travelled from heated igneous rocks far below the surface of the earth. Often (but not always) quicksilver is found in serpentine or near serpentine in the Franciscan formation, which the Jurassic serpentine intrudes. This is probably because the fractured serpentine extends to greater depths even than the faults, and serves as avenues for the ascending solutions, rising from the deep younger magmas. Today the Federal government is making intensive field investigations of some of these quicksilver deposits in California.

Chromite on the other hand, is a mineral of the serpentine or of the ultra-basic rocks from which the serpentine is hydrothermally altered. It was a product of the old Jurassic magma, which occurs in the Coast Ranges, Sierra Nevada, and Klamath Mountains. Generally the rich pockets of chromite are limited in size. Though there are many of these in California, the low-grade disseminated deposits are expected to yield, in the end, the greater tonnages. The government is now making investigations of this problem.

Some asbestos has been produced from serpentine in Napa County. There are many other minor occurrences of serpentine asbestos in California.

Nickel, though rare, is found in small quantities in serpentine in California. A small body of nickel occurs in San Diego County, on the contact of gabbro and schist, associated with a pegmatite dike. Nickel has also been found in Imperial County.

A small production of platinum may be accredited to California, as a by-product of placer gold-mining in the Sierra Nevada and Klamath Mountains. It was probably originally formed in serpentine.

Magnesite veins are found as a leached product of the serpentine. The serpentine is leached by waters, often quite hot, and charged with carbon dioxide, where such waters ascend along faults, sometimes the same faults along which the quicksilver entered. Magnesite comes very near being one of the deficient minerals. Magnesite is also made chemically from oyster shells and sea water, and there seems to be plenty of both in San Francisco Bay.

Manganese was originally deposited as carbonates with the siliceous red radiolarian cherts of the Franciscan formation. These cherts are lenticular in form and associated with basic volcanic rocks of the same formation. Surface weathering, decay of rocks, leaching, and superficial concentration has been the process of concentration of the limited supplies of black manganese oxides. The same process of formation in cherts is found not only in the Franciscan cherts of the Coast Ranges but in cherts of older rocks in the Sierra Nevada. Today the government is testing the low-grade manganese-bearing cherts to see if they can be used to advantage in time of war or peace.

Tungsten is found in Inyo County as large low-grade deposits of scheelite which occurs in the contact garnet rocks that lie between limestone and the intruding granitic rocks. In the contact metamorphosed limestone rocks, little grains of scheelite may be detected by means of the fluorescent lamp giving an ultra-violet ray, adapted for use by prospectors either underground, or at night on the surface. In San Bernardino County scheelite occurs in gold-quartz veins in schists cut by granite. Most of these deposits have recently been investigated by the United States government.

One of the very few and probably the largest of the rare tin deposits of the United States occurs in California. In the Temescal (Cajalco) tin district, in western Riverside County, veins with cassiterite occur in granite. The district actually has produced some tin, and though it is not productive today, it is now receiving thorough investigation by Federal geologists.

Not only does tin occur in granites and granite-pegmatites, but tungsten is apt to be found also in these rocks. Since Southern California, especially Riverside and San Diego Counties, contains many pegmatites it is reasonable to expect to find in this region more of these particular strategic minerals.

Also sheet mica, another strategic mineral, is a product of pegmatites and it is reasonable to expect occurrences of sheet mica in this same region. So far, only scrap mica has been produced in California, largely from schists.

In addition to tin, tungsten, and mica, it is quite possible that feldspar (suitable for use in manufacture of optical glass) and optical quartz crystal may be discovered, and serve in the capacity as strategic minerals, in this same southern region which abounds in pegmatite dikes. Some good quartz crystal has been found in the Mother Lode region, near Mokelumne Hill.

Some deposits of antimony occur in the southern end of the Sierra Nevada and San Emigdio Mountains, also in San Bernardino, Inyo and San Benito Counties and most of these have recently been examined by Federal geologists.

Though vanadium has not been produced in California, there are a number of occurrences of vanadium-bearing minerals in veins, principally in San Bernardino County, and also in the Mother Lode district.

From some of the brines of oil-well waters of Los Angeles County, iodine is commercially extracted. The extensive kelp or sea-weed of the Pacific Coast is another source of iodine.

Toluol, or toluene, used in very high explosives, is obtained as a product both from coal in the making of coke, and from petroleum, in the cracking process for gasoline. Toluol has not been made commercially in California, but could be, if it becomes necessary. Ordinarily it has been made from coal, but now a plant to produce toluol has been constructed in Houston, Texas, by the Shell Company.

In conclusion, it is apparent that California should play a very important role in supplying many of the much needed minerals of national defense, and the Geologic Branch of the Division of Mines, in cooperation with mining engineers and geologists employed by the Federal government, by universities and by private industry is making a study of the situation and making the results of the study available to the public.

It was originally planned, that the Geologic Map of California should be followed by a series of economic mineral maps, which would utilize the same base with the general geology already drawn upon this base, so as to show interrelationships between geological features and mineralization. This plan is now well on its way, for the Quicksilver Map, started four years ago, is now distributed far and wide receiving nothing but praise. *All* deposits known, not merely those of commercial importance, are accurately located upon this map, so as to show the trends of mineralization,—the knowledge of which is so helpful to persons employed in exploration for new deposits. A simple valuation has been made of the deposits, by varying slightly the symbols on the map so as to indicate, respectively, consistent, sporadic, and non-producers. These things, together with charts of various sorts, on geologic facts, mineralogy, production, uses, economics, etc., make the work fundamental to prospectors, engineers, and members of the United States Geological Survey and Bureau of Mines who are all seeking the most likely spots to carry on further exploration for national defense minerals.

In accomplishing this work, the Geologic Branch has been in close cooperation with various agencies. For personnel, to record many of the details and data, it has secured the help of highly trained graduate students of our best universities, who have undertaken separate tasks in connection with the preparation of theses for graduate degrees. The direction, guidance, and necessary additional details of the work have been done by the Geologic Branch together with other members of the staff of the Division of Mines. Valuable inventories of active mining properties are constantly being brought up-to-date by the District Mining Engineers. The results of their work are, of course, included in this broader state-wide survey. The scope of this work by the Geologic Branch, however, covers a broader field, primarily geologic in character, and is accomplished through extensive cooperation from many authoritative sources. Throughout all these undertakings, much assist-

ance has been received from the Federal Works Progress Administration.

So valuable and generally useful are these economic maps, that many persons seem impatient for their immediate completion. In the making of these maps, however, there are several factors which should be taken into consideration: (1) That the greater part of the work has been done by persons who are donating their services. (2) That the work was started by the Geologic Branch several years before the present World War, but in anticipation of it. (3) That the Geologic Branch is endeavoring to do the very best possible job of these maps. (4) That already has been published the most important map, i.e., Quicksilver,—published when the price was $200 a flask, but the preparation of the map was started when quicksilver was $75 a flask. (5) That material is now being assembled rapidly for the rest of the strategic minerals. (6) That the data on chromite and tungsten are already on hand ready for putting on the map. (7) That the Geologic Branch is very short-handed in paid assistance to accomplish the final preparation of the maps for publication. (8) That there are as yet insufficient funds to publish the material, once it is assembled.

Though not one of the "strategic" minerals, as so defined by the United States government, *oil* is really the greatest controlling factor in this present World War. In the mineral industry of California, this one overshadows all other products, and its consumption is equally enormous. Without new fields constantly being discovered to keep reserves ahead of utilization, the future of this essential industry would be dismal, indeed.

The most comprehensive bulletin on exploration and development ever published by the Division of Mines, is now in the making by the Geologic Branch. It is Bulletin 118, "Geologic Formations and Economic Development of the California Oil and Gas Fields." Issued in four extra large-sized parts and exceedingly well illustrated (the first part of which is already released), this bulletin describes not only the fields and tells not only of the development of the industry, but it is a treatise on the basic geology of the whole State, and especially of the region of the Coast Ranges. It is a significant fact that in the Coast Ranges also are located a very large amount of California's "strategic minerals"; examples,—quicksilver, chromite, and manganese. Nearly 150 professional men, highest in their fields as engineers and scientists, have contributed to this fine treatise on petroleum, which is being prepared with every care possible to make it the leading authority in the whole country. Accompanying the last part of the book (and folded in a pocket) will be an economic oil and gas map of the entire State, made on the same base and in somewhat the same manner as the Quicksilver Map, which has already won such world-wide praise. So far, subscriptions to the four parts of this bulletin have paid the way of the first part through the press.

DESCRIPTIVE GEOLOGY OF THE KERNVILLE QUADRANGLE, CALIFORNIA

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OUTLINE OF REPORT

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ABSTRACT

The Kernville quadrangle, the center of which lies approximately 50 miles northeast of Bakersfield, California, includes a large part of the southern Sierra Nevada, mainly the areas adjacent to the valleys of the Main Fork and the South Fork of the Kern River.

The area consists of a great central platform, approximately 7000 feet high, bounded on the east by the Sierran escarpment, at the base of which lies the Sierra Nevada fault, and on the west by the deep canyon of the Main Fork of the Kern River. The central platform is breached by an east-west valley, the floor of which lies 2500 to 3000 feet below the average elevation of the adjacent upland. This valley is occupied by the South Fork of the Kern River. Southward, the Piute Mountains and Kiavah Mountain, continue the plateau-like character of the central part of the quadrangle, with high, flat summits, cut by deep-trenched canyons.

The major structural feature is the Kern Canyon fault. The fault is mapped, evidence presented for its presence, and its geomorphic significance indicated. Two minor faults are also mentioned.

Metamorphic rocks of the area belong to the Kernville series, of probable Carboniferous (?) age, composed chiefly of quartzites, phyllites, schists, and marbles, which occur as huge inclusions in the plutonic rocks which have invaded them. The relationships, structure, mode of occurrence, and age are discussed.

Plutonic rocks outcrop over the greatest portion of the area. They comprise mafic (basic) intrusives, dominantly quartz diorites and gabbros; and a wide variety of silicic types belonging chiefly to one intrusive period. The oldest of the intrusive series is the Summit gabbro, varying from hornblende gabbro to biotite gabbro. This unit is closely associated with the Sacatar quartz diorite, varying from gabbro to granodiorite, which intrudes the Summit gabbro. The mafic units are both intrusive into the Kernville series. They are closely associated in time, space, and origin. The suggested date of intrusion of the mafic units is Permo-Carboniferous.

The Isabella granodiorite, varying to granite, quartz monzonite, and quartz diorite, comprises the final intrusive in the history of the area. These rocks invade all earlier sequences. This unit is deemed the equivalent of the widespread granitic types of the Sierran batholith, and is thought by most writers to be upper Jurassic. The relations, petrography, and distribution are discussed.

Dike rocks are found in the area in various places. Lamprophyres are rare, but aplite, pegmatite, and silexite are common.

Volcanic flows form small tablelands on the higher uplands of the quadrangle. They are chiefly olivine basalts and olivine andesites with some rare associated types.

Lacustrine and fluviatile silts and sands are found chiefly in the large meadows in the central part of the region. Two other series of alluvial deposits also occur.

INTRODUCTION

PROCEDURE OF STUDY

The study of the Kernville quadrangle, southern Sierra Nevada, California, was begun by the senior author (Miller) in 1928 as part of a program of study of the crystalline rocks of southern California. Some results of these early studies were embodied in a brief paper.[1] The work was advanced by the junior author (Webb) beginning in 1931, and continued to 1937, when he presented a study of the northern half of the Kernville quadrangle in partial fulfillment of the requirements for the degree, Doctor of Philosophy, at the California Institute of Technology. The writers, working together, completed the southern quarter of the quadrangle. This paper presents some of the results of these studies, including a geologic map of the area involved.

ACKNOWLEDGMENTS

Webb wishes to acknowledge the stimulation and help received from Dr. Ian Campbell, Associate Professor of Petrology, Balch Graduate School of the Geological Sciences, California Institute of Technology, under whom the thesis on the northern part of the quadrangle was completed. He also wishes to thank the entire geological faculty of the California Institute of Technology, and Robert P. Bryson, now of the U. S. Geological Survey, for their assistance. The authors wish to thank the many residents of the Kernville area for the assistance rendered. Grants in aid from the Board of Research of the University of California at Los Angeles are gratefully acknowledged.

GEOGRAPHY

LOCATION

The Kernville quadrangle includes more than 1000 square miles located in Tulare, Kern, and Inyo counties, in the heart of the southern Sierra Nevada. The region lies northeast of Bakersfield, and approximately 200 miles from Los Angeles. The quadrangle is crossed from east to west by various roads, the number of which have been increased recently by numerous truck trails installed for fire purposes.

CLIMATE

The climate of the southern Sierra varies greatly. In the Kernville area, the rainfall is less than fifteen inches per year. Snow occasionally falls over the entire region; this is unusual below 3500 feet. The daily temperatures of summer above the 6000-foot level are seldom greater than 90° F. Below the 6000-foot level, especially in deep valleys, high summer temperatures are common. The summer diurnal range is very great, especially above 7000 feet. Freezing temperatures on summer nights are not uncommon. From December to March, winter storms sweep the area every week to ten days. They usually bring slight precipitation, but are invariably accompanied by

[1] Miller, William J., Geologic sections across the southern Sierra Nevada of California: Univ. Calif. Pub. Bull. Dept. Geol. Sci., vol. 20, pp. 331-360, 1931.

strong winds. Summer thunderstorms bring unsettled weather which lasts from two to seven days at a time.

The climate of the region of the southern Sierra is classified by Russell [2] as Mesothermal, Csa and Cs'ab on the Köppen climatic classification.[3]

Field work is possible at elevations above 4000 feet from April 15, to the first winter storm in November or December. Below 4000 feet, field work can be carried on all year.

VEGETATION

The commonest trees in the region are the pines. The most common above 6000 feet are the western yellow pine and the western white pine. In some areas above 9000 feet, grow the whitebark pine and the sugar pine. Above 8000 feet are found the silver fir and the Jeffrey pine; from 5000 to 7000 feet, the incense cedar; and below 5000 feet along watercourses, the gray digger pine. In the eastern physical divisions occur extensive growths of the pinyon. In the same area the junipers are common. The tamarack is found in groves on the central uplands.

The oaks are confined, with a single exception, to areas lower than 4000 feet. The California black oak grows from 4000 to 8000 feet. The canyon live oak grows in the lower valleys.

Alders, poplars and cottonwoods, aspen and willows are very common up to 8500 feet around waterholes, springs, and streams.

On the desert areas of the lower slopes and the South Fork Valley, grow the yucca and the Joshua tree.

Of the shrubs, the mountain mahogany, the buckthorn, and the manzanita are common in dense thickets, below 5000 feet.

Flowers and grasses grow profusely throughout the summer at elevations above 7000 feet.

PREVIOUS GEOLOGIC STUDY IN THE SOUTHERN SIERRA

Several papers have been published on geomorphologic features of certain parts of the southern fifth of the Sierra Nevada, but remarkably little has been printed on the character, distribution, age relations, and origin of the rocks themselves.

The earliest reference found was by R. S. Williamson,[4] who briefly mentioned certain physiographic features of the Kern Rivers and described the setting around Walker Pass. Goodyear [5] published a paper dealing mainly with the mineral resources, but which contained some information regarding the rocks found, particularly along the main valley of the Kern. No detailed observations were made, however. A paper briefly describing some of the general geomorphic features along the Kern River appeared in 1897.[6]

Olmstead [7] studied the course of the Kern River for possible dam sites, and published a paper in which some hydrographic data are given.

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[2] Russell, R. J., Climates of California; Univ. Calif. Pub. in Geog., vol. 2, pp. 73-84, 1936.

[3] Köppen, W., Die klimate der erde: (Berlin), 1923.

[4] Williamson, R. S., Geological report of exploration and surveys of Railroad Routes to the Pacific: vol. 5, Pt. 1, pp. 14-18, 1856.

[5] Goodyear, W. A., Kern County: Calif. State Min. Bur., State Mineralogist's Rept. 8, pp. 309-324, 1888.

[6] Drake, N. F., The topography of California: Jour. Geol., vol. 5, pp. 563-578, 1897.

[7] Olmstead, F. H., Physical characteristics of Kern River, California: U. S. Geol. Surv. Water-Supply Paper 46, pp. 11-38, 1901.

Lawson [8] published a study on the physiographic features of the Kern River in an area a short distance north of the Kernville quadrangle. This was followed by a second paper [9] which described the geomorphologic features of the Kern River Canyon in the Kernville quadrangle, and of areas slightly to the south. A third study, of the region to the south of the Kernville quadrangle, followed.[10]

In a paper embracing a large desert area to the east, Baker [11] briefly discussed in general terms some of the physiographic features of the eastern portion of the Kernville quadrangle. Buwalda [12] mentioned the structural features of the region to the south, and again in 1920 [13] and 1934 [14] presented further structural data on the same area. Hake [15] presented a discussion of faulting in the southwestern Sierra Nevada, and an hypothesis for the explanation of certain geomorphic features.

Louderback [16] reported on geologic conditions of Isabella Reservoir site in Hot Springs Valley near Isabella in the course of damsite surveys by the State of California.

Forbes [17] re-examined the Isabella Reservoir site and briefly discussed the geologic setting.

Marliave [18] further discussed the geologic setting around Hot Springs Valley.

Mayo and associates[19] have been studying recently broad structural relations in the Sierra and have considered the southern Sierran pattern.

The only papers treating the detailed petrology and structural geology of the Kernville quadrangle are those which have appeared by the present writers. Miller[20] discussed the petrologic relationships of a geologic section across the area of detailed study, and for areas adjacent east and west. In the paper he outlined the geologic units, structure, kinds, ages, and mode of emplacement of some of the rocks

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[8] Lawson, A. C., Geomorphogeny of the upper Kern Basin: Univ. Calif. Pub., Bull. Dept. Geol., vol. 3, pp. 291-386, 1904.

[9] Lawson, A. C., Geomorphic features of the Middle Kern: Univ. Calif. Pub., Bull. Dept. Geol., vol. 4, pp. 397-409, 1906.

[10] Lawson, A. C., The geomorphogeny of the Tehachapi Valley System: Univ. Calif. Pub., Bull. Dept. Geol., vol. 4, pp. 431-462, 1906.

[11] Baker, C. L., Physiography and structure of the western El Paso Range and the southern Sierra Nevada: Univ. Calif. Pub., Bull. Dept. Geol., vol. 7, pp. 117-142, 1912.

[12] Buwalda, J. P., Structure of the southern Sierra Nevada: Bull. Geol. Soc. Amer., vol. 26, p. 403, 1915.

[13] Buwalda, J. P., Fault system at the southern end of the Sierra Nevada, California: Bull. Geol. Soc. Amer., vol. 31, p. 127, 1920.

[14] Buwalda, J. P., Tertiary tectonic activity in the Tehachapi Region: (*abst.*), Geol. Soc. Amer. Proc., 1934, p. 312, 1935.

[15] Hake, B. F., Scarps of the southwestern Sierra Nevada, California: Bull. Geol. Soc. Amer., vol. 39, pp. 1017-1030, 1928.

[16] Louderback, G. D., Report on geological conditions in Hot Springs Valley in connection with Isabella Reservoir site, *in:* "Water Resources of Kern River and Adjacent Streams and their Utilization," Calif. State Dept. of Engineering, Bull. No. 9, pp. 134-7, 1920.

[17] Forbes, Hyde: Geologic reports on dam sites in the San Joaquin River Basin: Isabella, Borel, and Bakersfield dam sites on the Kern River. The San Joaquin River Basin, Calif.; Dept. of Public Works, Div. of Water Resources, Bull. No. 29, Appendix C, pp. 598-606, 1931.

[18] Marliave, Chester, Geological reconnaissance report on Isabella dam sites situated on Kern River in Kern County, State of California, Dept. of Public Works, Div. of Water Resources, pp. 1-23, 1938.

[19] Mayo, Evans B., Orogeny in southern Sierra Nevada. (*abst.*) 37th An. Meet., Program, Cord. Sec. Geol. Soc. Amer., Stanford Univ., 1938, p. 22.

Locke, Augustus, Billingsley, Paul, and Mayo, Evans B., Sierra Nevada tectonic pattern. Bull. Geol. Soc. Amer., vol. 51, pp. 513–540, 1940.

[20] Miller, William J., *op. cit.,* 1931.

of the area. Webb[21] discussed features produced along the Kern Canyon fault, and in a later paper[22] discussed special features of the plutonic-metamorphic complex.

The areal mapping of the Kernville quadrangle was contributed to the Geologic Map of California[23] which was recently published.

SUMMARY OF GEOMORPHOLOGIC FEATURES

The Sierra Nevada is, broadly viewed, a great geomorphic province of homogeneous form. Its simplicity was early recognized by Le Conte[24] when he showed it to be a great tilted fault block, in which he recognized complications that have since been much investigated. The southern Sierra, including the Kernville quadrangle, is not truly a tilted block, but is a horst block of rather simple form, without westward tilt. The Kernville area appears as a great high platform, sloping gently southward, with evenly elevated summits. Its description and geomorphologic interpretation will be presented later in a separate paper.

The Kernville quadrangle lies within the Sierra Nevada, which forms a rugged chain more than 400 miles long and nearly 60 miles wide, with a northerly trend. The range is bounded on the east by the great Sierra Nevada fault zone. Immediately west of this fault, lies the Kernville quadrangle. The higher altitudes range between 7000 and 9500 feet, with Sirretta Peak, in the north-central part, marking the highest point at 9956 feet. The region has been deeply dissected by streams which have carved out canyons with depths of 3000 to 4000 feet. Greatest of all are the canyons of the main Kern River and the South Fork of the Kern. The long, wide, nearly flat-floored South Fork Valley lies only 2500 to 3000 feet above sea level. The floor of the valley is almost a desert, irrigated in part, into which alluvial fans extend from both sides. The stage in the cycle of erosion represented in the southern Sierra Nevada region is that of late youth. Various parts of an old upraised surface have been only moderately affected by erosion, as, for example, the rather sharply defined plateau from three to twelve miles wide between the Main Kern River and the South Fork of the Kern River. Drainage of all streams is ultimately into the southern San Joaquin Valley (Buena Vista Lake), via the Kern River.

The quadrangle contains several named mountain masses which are parts of the Sierra Nevada. The regions south of the South Fork Valley are part of the Piute Mountains, a large, rugged mountainous area rising to more than 8000 feet, deeply dissected by streams flowing radially outward from the range. East of the Piute Mountains, separated from them by a deep alluviated valley, lies Kiavah Mountain, a flat-topped summit area not yet as completely dissected as the adjacent Piute, and lying at a lower elevation, about 6000 feet. North of the South Fork Valley a huge upland, containing the highest elevations

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[21] Webb, Robert W., Kern Canyon fault, southern Sierra Nevada, Jour. Geol., vol. XLIV, pp. 631-638, 1936.

[22] Webb, Robert W., Relations between wall rock and intrusives in the crystalline complex of the southern Sierra Nevada of California: Jour. Geol., vol. XLVI, pp. 310-320, 1938.

[23] Jenkins, Olaf P., Geologic Map of California, Cal. State Division of Mines, 1938.

[24] LeConte, Joseph, On the origin of normal faults and of the structure of the Basin region: Amer. Jour. Sci., 3rd Ser., vol. 38, pp. 257-263, 1889.

in the region is found. It is locally subdivided into three parts (1) the Bartolas Country (2) the domelands and (3) the meadowlands. These uplands are separated from one another by rather shallow alluviated valleys. To the west, separated from this upland by the canyon of the Main Fork of the Kern River, and bounded by a steep escarpment, lie the Greenhorn Mountains. This prominent topographic feature extends westward to the margin of the Sierra Nevada at the edge of the San Joaquin Valley.

ROCKS OF THE REGION

THE KERNVILLE SERIES

Introduction

The metamorphic rocks belong to the Kernville series, a name proposed by Miller[25] for the meta-sedimentary formations exposed in the vicinity of Kernville, California. The distribution of the Kernville series is indicated on the accompanying geologic map.

General Description

The Kernville series is made up very largely of phyllite, quartzite, and crystalline limestone, with a small percentage of pyroclastics and rolled gneiss. In the southern part of the quadrangle the most abundant of these is the phyllite which varies locally to mica schist, particularly along contacts with invading granitic rocks. The phyllite is highly foliated, yielding thin plates, and is a greenish-gray to grayish-black color. Thin-bedded light gray to dark bluish-gray quartzites are usually interbedded with the phyllite, the quartzite in some places making up about half of the mass. Many bodies in the northern part are composed almost entirely of quartzite. The marbles are nearly everywhere crystalline, calcitic, white to bluish-gray, thick-bedded, fine to moderately coarse-grained, and almost invariably fetid. Beds of white marble, ranging from a few to several feet in thickness, are associated with bluish-gray and banded white crystalline limestone.

Description of Areas

Along the Main Fork of the Kern: Within the canyon of the Kern River are several large areas of the Kernville series, extending from Kernville and Isabella on the south to the northern boundary of the quadrangle. These are in general composed of phyllites, with some quartzite and marble; especially in the northern part of the canyon does the percentage of marble become large. The structure is fairly uniform in most of these sections, with the strike, usually about N. 30°-40° W., and easterly dips, from 65° to 85°, more commonly the latter. An east-west section through the middle of the canyon exposes fully 3000 feet of the Kernville series. This series crops out along the main canyon of the Kern for more than 15 miles to the north. In the northern part, near Fairview, some folding is seen, which complicates the estimation of thickness. Detailed mapping in the northern area failed to bring out any tectonic pattern. In many places metamorphic units are cut by tongues of the later intrusive

[25] Miller, William J., *op. cit.*, p. 335, 1931.

rocks, although cross-cutting relations are rare, the contacts mostly being accordant with bedding and foliation of the Kernville series.

East of Bodfish: A large area of the Kernville series is exposed east and southeast of Bodfish. Several canyons in this area are strike canyons cut along weaker belts in the Kernville series. The strike is uniform, N. 40°-50° W., with high angle dips, usually 80° S. to 80° N. The rock types of this area differ somewhat from those elsewhere encountered in the Kernville series. The belt of meta-sediments is about three miles wide, with a regular medial sequence composed almost entirely of meta-volcanic rocks—mostly altered lavas of basaltic or andesitic type. This is the only area of the Kernville series in which meta-volcanic rocks comprise more than a small percent of the total mass. On either side of this thick zone of meta-volcanics, one finds small, thin-bedded layers of quartzite, which grade laterally into crystalline arenaceous limestones and finally into marble. The crystalline limestones serve as host to large intrusive bodies which cut the Kernville series on either side. In some places, the invading rock has cut great gaps from these marginal crystalline limestones, but in general the marble layers are intact and have protected the Kernville series in its inner parts from the invading rock. The relationship here seen indicates the presence of a large anticlinal fold, since the rock dips steeply across the contacts with the intrusives on either side, with nearly vertical dips in the inner parts. The strikes are uniform throughout. The thickness involved in the two limbs of the fold is in excess of 15,000 feet.

East of Isabella and South of Weldon: The area of the Kernville series lying between Isabella and Nichols Peak, and south of Weldon, extending southeastward consists of phyllite, locally metamorphosed to mica schist, crystalline limestone, and a smaller amount of quartzite. Southwest of the marble lens lying 2½ miles east of the top of Cook Peak, some beds of conglomerate-gneiss were found interbedded with mica schist. Flattened pebbles of quartz half an inch wide and three inches long occur in the gneiss. Several other outcrops of rolled gneiss occur in the Kernville series in this area, as well as elsewhere. Gray, thin-bedded quartzite and lenses of coarse crystalline limestone are found, some of the marble lenses being especially long and conspicuous. In these lenses toward the southeast much wollastonite has developed in certain beds, with some tremolite, and considerable garnet and diopside. All of these minerals have resulted from the addition and subsequent reaction of siliceous material with the calcareous beds. In some places, sillimanite-biotite-quartz schists occur as well as some muscovite-sillimanite schists. The general strike of the Kernville series in this area is N. 45° to 65° W., with generally steep easterly dips, exceeding 70°. It is conservatively estimated that the thickness of the Kernville series in this area is in excess of 12,000 feet.

One conspicuous feature of the marble beds in the Kernville series, particularly well shown in this area, is the abrupt ending of some of the thick layers. For instance, the long continuous crystalline limestone belt several hundred feet thick crossing South Fork Valley (see geologic map) abruptly wedges out in less than 300 yards. A careful study in the area fails to reveal the slightest evidence of faulting.

The strike of the marble layers is continued by thick quartzites and phyllites which have all the appearance of enveloping a disappearing crystalline limestone lens. This is also true of several other large marble beds in the same region. Faulting can not be invoked since no offset in adjacent beds can be seen. To the southeast, this unit of the Kernville series dies out, where it is extensively invaded by granitic rocks.

East and Southeast of Rockhouse Basin: An area of over 75 square miles of the Kernville series is found in the eastern part of the quadrangle. It is composed chiefly of carbonaceous platy black phyllite with subordinate fine-bedded, white to gray quartzite, and some coarsely crystalline, fetid marble beds, many of which are replaced by barite. The estimated thickness of this series, assuming that it is continuous and in normal stratigraphic relation, is more than 15,000 feet. A small quantity of metamorphosed pyroclastic material is intercalated. The attitude of these rocks is very uniform, being N. 40°-50° W., with dips of 80°, mostly to the east. Single beds, particularly marble, are often traceable for some distance. Marginally, accordant intrusion has altered some of the rocks, where one finds in marbles silicated areas in which garnet, wollastonite, and diopside are developed, along with minor minerals.

Northwest of the Dome Land: An extensive body of the Kernville series, striking N. 40°-60° W. with steep dips, crops out northwest of the Dome Land, extending into the Olancha quadrangle to the north. Lithologically, this area is similar to others described above, except that the eastern 4000-6000 feet of the series is composed dominantly of phyllite, while the western 5000-7000 feet is made up almost wholly of a white, poorly bedded, ''fish-eye'' quartzite, which outcrops boldly, particularly in the stream canyons, where excellent thick sections are exposed. Furthermore, around this area of the Kernville series is an aureole of gneisses which, it appears, has been formed by reaction and injection during the intrusion of the surrounding granitic rocks. This aureole is about a quarter of a mile wide on the average. There are few associated marble zones, although to the north in the Olancha quadrangle, continuous with this same belt, one finds considerable marble.

Areas North and West of Sirretta Peak: There are three separate areas of the Kernville series north and west of Sirretta Peak. These are long and narrow, varying from 2 to 3 miles in length by less than 500 yards in width to larger areas 5 to 6 miles in length by half a mile in width. These septal-like inclusions are composed entirely of the one rock type, quartzite, and its variants. It is invariably the only rock present. Similar septal-like inclusions were found by Mayo,[26] to the north, but were found nowhere else in the Kernville quadrangle. These septal remnants reflect both the regional and internal attitudes of other areas of the Kernville series, namely N. 45°-55° W., dipping in most cases vertically, but never less than 80° one way or another.[27]

[26] Mayo, Evans B., Some intrusions and their wall rocks in the Sierra Nevada, Jour. Geol., vol. XLIII, pp. 673-689, 1935.

[27] Wall rock intrusive relations in these areas are discussed in greater detail in a paper by Webb, *op. cit.*, 1938.

Summary of Lithology of Kernville Series

Because of their marked lithologic similarity across the entire region, and since no stratigraphic break was found anywhere, all of the metamorphosed strata above described are grouped into a single series—the Kernville. In view of the facts that no fossils were discovered after careful search, and that the areas of the Kernville series are so widely scattered, it must be admitted that the Kernville series may represent more than one formation; but there is no positive evidence of this. It is probable that the scattered areas represent merely remnants of once very widespread strata with a conservatively estimated thickness of at least three miles.

Age of the Kernville Series

No material has been obtained from the Kernville series that is definitely known to be of organic origin. Careful search has revealed only two occurrences that are at all suggestive of fossils. One arenaceous phyllite contains some elongate rods and spines which simulate graptolites; they are so poorly preserved that it is impossible to state what they are. A second occurrence shows incrustations of calcareous material in circular form which suggests algal forms similar to those found in some Proterozoic rocks. All available evidence, however, seems to indicate that these are in all probability inorganic; at any rate age determinations from either of these specimens, even though they may prove to be organic, would be impossible because of the poor preservation.

Inferences regarding age, however, can be drawn from other facts. It is now fairly well established that there are present at least two ages of metamorphic rocks in the Sierra; the Mariposa, of Mesozoic age; and the Calaveras, of late Paleozoic age. In the northern Sierra, fossil evidence permits the partial separation of the sedimentary series into their proper sequences. Recently Mayo [28] has presented evidence to show that the east-central Sierra contains meta-sediments of Devonian age.

Lithologically, the sediments of the Kernville series resemble closely the Calaveras. This is particularly apparent when comparing them with descriptions such as those given by Knopf [29] for the Calaveras and Mariposa. Furthermore, as has been indicated in an earlier paper,[30] the Kernville series is distinctly more highly metamorphosed than the Mariposa. While this criterion is admittedly open to criticism as a basis for age determination, nevertheless it suggests the more probable Calaveras age for the Kernville series. In the absence of fossil evidence, however, it may be that either the Mariposa is wholly or partly the equivalent of the Kernville series, or that neither the Calaveras nor the Mariposa are correlatives of the Kernville. The writers feel strongly, however, that the more probable age assignment, on the basis of lithologic similarity, is Calaveras.

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[28] Mayo, Evans B., Fossils from the eastern flank of the Sierra Nevada, California, Science: vol. 74, pp. 514-515, 1931.

[29] Knopf, Adolph, The Mother Lode system of California: U. S. Geol. Surv. Prof. Paper 157, pp. 10-12, 1929.

[30] Miller, William J., *op. cit.*, p. 342, 1931.

It is significant that rocks described in the Convict Lake area [31] to the north as early Paleozoic differ somewhat in lithology from those of the Kernville area. Furthermore, meta-volcanic rocks, which are notably subordinate in the Kernville series, associated with the meta-sediments of the Convict Lake area are assigned by Mayo [32] to the Triassic on the basis of age determinations made to the south by Knopf [33] in similar rocks.

G. H. Anderson,[34] in discussing metamorphic units in the Inyo-White Mountains of eastern California and western Nevada, describes a complex series of non-fossiliferous meta-sedimentary rocks which are tentatively assigned to the Cambrian and pre-Cambrian. They differ markedly in lithology and are more highly metamorphosed than the Kernville series. It seems probable that these rocks are older; they seem to have more similarity to the Devonian rocks described by Mayo.[35]

On the basis of the points discussed above, the writers tentatively assign the Kernville series to the upper Paleozoic, probably Carboniferous; it is most likely the equivalent of the Calaveras.

PLUTONIC ROCKS

Introduction

The writers have mapped three intrusive units in the Kernville quadrangle: (1) a gabbro, intimately associated with (2) an hornblende-quartz diorite and (3) a granodiorite, with many facies. The gabbro and quartz diorite are intimately associated in time and space.

Mafic Units

Summit Gabbro

Areal Distribution: The Summit gabbro is so named because of prominent exposures along the crest of the Sierra in the northeastern part of the quadrangle. Other large exposures of Summit gabbro are found in the central western portion of the area. Large areas outcrop near the summit of Walker Pass, where the gabbro is intimately associated with the quartz diorite mentioned above. The geologic map must be studied to visualize the areal distribution of the Summit gabbro.

Petrographic Description: The Summit gabbro is typically medium to fine-grained, with occasional coarse-grained facies. The chief minerals visible in hand specimen are finely twinned plagioclase, of a bluish to greenish-gray color; varying amounts of hornblende; a little biotite; and considerable pyrite. Some parts are nearly devoid of dark minerals. Microscopically, the volume percentage composition as determined from thin-sections is as follows: laboradite to bytownite (An_{70} to An_{80}),

[31] Mayo, Evans B., Geology and mineral deposits of Laurel and Convict Basins, southwestern Mono County, California: Calif. Jour. Mines and Geol., vol. 30, pp. 79-87, 1934.

[32] Mayo, Evans B., *op. cit.*, p. 679, 1935.

[33] Knopf, Adolph, A geologic reconnaissance of the Inyo Range and the eastern slope of the Sierra Nevada, California: U. S. Geol. Surv. Prof. Paper 110, 130 pages, 1918.

[34] Anderson, George H., Geology of the north half of the White Mountain quadrangle, California-Nevada: Doctorate Thesis presented to the California Institute of Technology, 1933. *Published in part:* Granitization, albitization, and related phenomena in the northern Inyo Range of California-Nevada, Bull. Geol. Soc. Amer., vol. 48, pp. 1-74, 1937.

[35] Mayo, Evans B., *op. cit.*, 1931.

80; hornblende, 18, which is commonly altered to epidote; and pyrite, 2. Post-consolidation alteration is indicated by epidote, and chlorite, in the hornblende; sericite and calcite, in the plagioclase. Fracture veinlets crossing grain boundaries are filled with quartz. Alteration is also prominent along grain boundaries. Secondary pyrite and occasional grains of magnetite surround other minerals. All minerals show evidence of strain. Undulatory extinction in the feldspars and bent cleavages both in the feldspars and in the hornblende are common. The rock has hypidiomorphic texture, with cataclastic (even mortar) textures in some grain combinations. In the western part of the quadrangle was found one small area of olivine gabbro, and another facies containing considerable diallage. In some mapped areas of the gabbro (notably the one north of Walker Pass) intimate association of the gabbro with the quartz diorite makes separation difficult, although the writers have attempted to generalize when the two types are mixed.

Sacatar Quartz Diorite

Areal Distribution: The Sacatar quartz diorite is named from the excellent exposures of this rock in Sacatar Canyon in the northeastern part of the quadrangle, which is occupied almost entirely by the Sacatar and its facies. In other parts of the area, at least west of the Rockhouse Basin, there are no exposures of the Sacatar, except perhaps one or two small areas in the Kern River canyon which may be related to the Sacatar. Lithologic similarity of certain facies of the Sacatar to the granodiorite which is widespread in the area sometimes makes it difficult to be certain of the affinities of the type.

Petrographic Description: Megascopically the quartz diorite is a mesocratic rock of medium to fine grain, with equigranular texture. Inspection shows a light-colored feldspar on which occasional twinning lines may be seen, abundant hornblende, some biotite, and a few grains of magnetite. Porphyritic facies are absent. Examination of thin sections of the quartz diorite shows the composition of the Sacatar unit to vary from an hornblende diorite and biotite-hornblende-quartz diorite, to microcline-quartz diorite. The unit averages a quartz diorite, with hornblende predominating over biotite, although occasionally the reverse is true. Average volume percentage composition is as follows: andesine (An_{40}), 68; quartz, 12; orthoclase or microcline or both, 5; hornblende, 10; biotite, 3; apatite, sphene, magnetite, and ilmenite, 2. Alteration is generally moderate, with leucoxene in both the ilmenite and sphene; epidote and sericite (in the andesine); a little kaolinite (in potash feldspars); and occasionally oxides of iron. There is some textural indication of the secondary introduction of sphene. The andesine is locally zoned; here selective alteration, more intense toward the core, is common. Apatite occurs in long needles which cross grain boundaries, and which are generally bent. Sphene often fills the interstices between biotite grains. Magnetite commonly fills small fractures in the andesine.

The texture of the typical quartz diorite is hypidiomorphic, inequigranular, but not megascopically porphyritic. Plagioclase is subhedral to euhedral. In some cases intense pseudo-cataclastic and cataclastic textures are developed. Indications of probable late stage

alteration are noted in the development of intergrowths, generally myrmekitic, but in some places graphic. Strain is shown by bent twinning lamellae on the plagioclase, bent biotite cleavages, undulatory extinction in all the felsic constituents, and broken and bent apatite needles where they cross grain boundaries. Pressure effects seem more prominent in this unit than in any other of the plutonic suites.

Facies of the Quartz Diorite: Certain parts of the quartz diorite unit have megascopic characteristics which are similar to the Summit gabbro. Microscopic studies of these facies indicate the association with and similarity to the Sacatar quartz diorite rather than with the Summit gabbro, although some evidence favors association with the latter, such as greater calcic content in the plagioclase, and decrease in the percentage of accessory minerals. Indeed, the wisdom of attempting a separation of the Sacatar quartz diorite and Summit gabbro might be questioned, as they are undoubtedly closely associated in age and origin. However, there exists in the region a well-defined gabbro unit, and a well-defined dioritic unit. The gabbroic facies is found in very small areas, grading laterally into the Sacatar quartz diorite. There is no evidence, where such is the case, that the gabbro is any earlier than the quartz diorite in which it occurs. On the other hand, where true Summit gabbro is adjacent, evidence is always clear for the intrusion of the quartz diorite into the gabbro. The gabbroic facies of quartz diorite is commonly finer grained than the normal Summit gabbro. Local porphyritic facies of the gabbroic variation are seen. Strong evidence in favor of the relations between Summit gabbro and the gabbroic facies of Sacatar quartz diorite as outlined above lies in the fact that the Sacatar quartz diorite is, in certain parts, highly contaminated with inclusions and schlieren which are interpreted as xenoliths, from the Summit gabbro. In such cases, some of the gabbroic facies of the Sacatar also contain finer grained inclusions of the older gabbro.

Certain facies of the Sacatar have the composition of granodiorite. As there are wide areas of typical Sierran granodiorite in the region, the writers often experienced considerable difficulty in differentiating these from the granodioritic facies of the Sacatar. In such cases, determinations were made on the field associations. After microscopic examination of the rocks of the region, it was found that one fact aided the differentiation. The granodiorite in this region (particularly in the northern part of the quadrangle) tends on the average toward a true granite, with quartz monzonite to granodiorite facies. Thus in those granodioritic rocks closely associated with the Sacatar quartz diorite, the quartz content is so much lower than in the Isabella intrusive that one can sometimes use this fact to differentiate these facies. The granodioritic phase of the Sacatar quartz diorite is somewhat finer grained than is the normal granodiorite, and has a higher percentage of dark minerals, chiefly biotite.

In the northeastern part of the quadrangle are mapped areas of "contaminated quartz diorite." These areas contain an especially large number of inclusions of fine-grained gabbroic material. These inclusions approximate the Summit gabbro in texture and composition. They occur in countless thousands within relatively limited areas.

Intrusive Relations of the Mafic Units

The Summit gabbro intrudes the Kernville series for the most part accordantly, but in one or two places with slight discordance. It is in turn intruded by the Sacatar quartz diorite, as irregular invading tongues, dike-like masses, and with some banded injection. The two units are closely related in time and often the contacts between gabbro and quartz diorite are gradational, with contacts such that the diorite must have invaded before the gabbro was completely congealed. Textural and mineralogical relations of the two units indicate that they must have been derived from the same parent magma, probably by differentiation immediately before emplacement. Textural similarities indicate a similar environment of crystallization. As already indicated, intimate relations of the two units are common, and they thus can not be separated either in time or origin.

Age of the Mafic Units

The age of the gabbro-diorite units of the Sierra Nevada has been debated since Turner, Ransome, and Lindgren first mapped them in the early folios of the United States Geological Survey. In these folios, the basic intrusives are grouped with those now thought to be of early to middle upper Jurassic age,[36] as pre-Cretaceous intrusive rocks. In these early works, however, evidence suggested the fact that the basic intrusives were earlier than the more silicic, and that it was at least possible that some of the basic rocks intruded only the Calaveras formation, considered as Carboniferous. Thus some intrusive activity was suggested before the deposition of the Mariposa. Since, various attempts have been made to prove the Carboniferous (Permo-Carboniferous) age of the basic intrusives. These have met with but partial success since (1) paleontological evidence is lacking, and (2) difficulty is experienced in separating those basic intrusives associated with the Jurassic (?) granitic invasions and those intruded by these invasions.

Knopf[37] suggests that some of the diorites of the Mother Lode district were late Carboniferous, and offers some important evidence in support of this hypothesis. Furthermore, Matthes[38] points out that there were dioritic intrusives which probably accompanied Permo-Carboniferous orogeny in the Sierra Nevada.

The writers concur in the belief that the diorite-gabbro series of the southern Sierra is probably older than the main composite Sierran intrusive. Since no paleontologic evidence is available from the Kernville series, it is impossible to date the mafic intrusives accurately. They are post-Kernville, and pre-granitic batholith. That they are considerably older than the granitic intrusives is suggested by (1) the greater evidence of metamorphic effects in the basic intrusives (2) the presence of two diorites in the region, one distinctly older than the other as shown by (a) associations (b) intrusive relations and (c) textural characteristics. It is realized, however, that the facts suggested above merely prove the earlier date of intrusion, and that the

[36] Anderson, Frank M., Knoxville-Shasta succession in California: Geol. Soc. Amer. Bull., vol. 44, pp. 1237-1270, 1933. Hinds, N. E. A., The Jurassic age of the last granitoid intrusives in the Klamath Mountains and Sierra Nevada, California: Amer. Jour. Sci., 5th ser., vol. 27, pp. 609-620, 1934.

[37] Knopf, Adolph, *op. cit.*, p. 19, 1929.

[38] Matthes, Francois E., Geography and geology of the Sierra Nevada; XVI International Geol. Congress Guidebook, Excursion C-1, pp. 26-40, 1933.

suggested Permo-Carboniferous age of the diorite-gabbro can not be established with certainty.

Isabella Granodiorite

Areal Distribution: The Isabella granodiorite, varying to granite, quartz-monzonite, and quartz-diorite, was so named by Miller[39] from typical exposures near the town of Isabella. Granite facies of the Isabella unit are more common in the northern part of the quadrangle, especially in the vicinity of Rockhouse Basin, than they are in other parts of the region. Typical granodioritic facies are more common along the valleys of the South Fork and Kiavah Mountain. The rocks of this unit underlie by far the largest area of any of the units of the region.

Petrographic Description: Typical specimens of the Isabella granodiorite are medium to coarse-grained, leucocratic rocks.[40] Porphyritic textures are occasionally developed; phenocrysts, generally of a potash or finely twinned sodic feldspar, are small. Quartz is abundant in small anhedral grains. Very small grains of mafic constituents are present, usually biotite in almost invisible flakes. The general textures are allotriomorphic granular. Deep weathering of the Isabella unit makes the selection of hand specimens difficult. The average rock shows the following volume percentage composition: quartz, 30; orthoclase and/or microcline, 30; oligoclase-andesine (An_{30}-An_{40}), 30. Accessory minerals range from 0 to 10 percent, usually considerably less than the latter. Common varietal and accessory minerals are biotite, hornblende, muscovite, apatite, epidote, sphene, magnetite. Kaolinite, sericite, hematite, and a little chlorite are commonly found. Sphene is found in large quantities in some facies. The quartz often contains myriads of small needles of bluish apatite. Undulatory extinction is common only in the quartz. The plagioclase is zoned, with the more calcic cores altering to epidote and with unaltered sodic parts. Some facies of the Isabella unit have been separated in mapping; others are indefinite areally or not in mappable units.

Facies of the Granodiorite: In certain areas within the main Isabella unit, especially along the main fork of the Kern River, specimens selected at random can not be distinguished from the Sacatar quartz diorite. The delineation of these units in mapping is based entirely on field relations. Two such areas are mapped separately in the areal pattern.

A facies of the Isabella that is commonly encountered with random relationships (though commonly marginal) to the parent mass is a coarse foliated granite, in which large anhedral quartz grains alternate in coarse bands with potash and soda feldspars in a highly foliated, leucocratic, equigranular rock having the composition of granite. It was found impractical to map this separately. The distinct linear parallelism of the minerals is excellently shown in many hand specimens;

[39] Miller, William J., *op. cit.*, p. 344, 1928.

[40] The rock of the sequence as found in the vicinity of Isabella was petrographically a granodiorite, and was thus named by Miller in 1930. Subsequent study has shown the more abundant presence of quartz-monzonite in the Kernville quadrangle, rather than granodiorite. It is considered best to retain the designation "Isabella granodiorite," however.

it is crudely shown in thin section. Rocks of this type are commonly alaskites.

In several places, areas of moderately grained Isabella granodiorite locally contain numerous crystals of orthoclase, individual and twinned (Carlsbad), which vary from a fraction of an inch to 1½ inches in size. They are non-uniform in composition, containing within the crystal boundaries of the feldspar, quartz, orthoclase, and biotite. They are similar to many found in other areas of the Sierra Nevada, and exhibit on a small scale many of the features of the giant crystals of the porphyritic rocks described from near Twenty-Nine Palms, California.[41]

Mappable units of pegmatitic granite, composed of coarse graphic intergrowths of quartz, orthoclase and microcline, in large masses, occur in the central part of the great interior platform of the quadrangle, north of Bartolas country. Some of the large domes are composed of this rock. Pneumatolytic minerals are absent in this phase, however.

Intrusive Relations of the Isabella Granodiorite: The Isabella unit cuts all other crystalline rocks in the area. That there were periodic invasions of the granodiorite batholith rather than a single wave of emplacement is shown by (1) the graded contacts sometimes found within the Isabella itself, between its various facies and (2) by the textural and mineralogic variations in the Isabella, which indicate that the Isabella was emplaced first in one area and then in another until the entire granitic batholith was emplaced as a series of connected intrusions, over a relatively short period of geologic time, and yet as separate waves of intrusion. Cutting the Isabella are many dikes, mostly of aplite and pegmatite; these are the only crystalline units later than the Isabella.

Age of the Isabella Granodiorite: No new data have been uncovered whereby it is possible to date the Isabella intrusive. It has long been supposed to have been emplaced in the late Jurassic or earliest Cretaceous, and there is considerable evidence in support of the former. Since no new data have been uncovered, the reader is referred to a summary paper[42] in which most of the available evidence is summarized. It is assumed by the writers on the grounds of (a) lithologic similarity (b) sequence of intrusions and (c) similar field relations, that the Isabella is the equivalent of the other Sierran granitic rocks, which have heretofore all been considered as belonging to a single parent in time and origin.

MIXED ROCKS

There are several areas within the quadrangle that are indicated as mixed rocks. In general, these are composed of rocks of the various intrusive units, intimately mixed so that mappable units are not present. They usually, though not always, contain remnants of the Kernville series, also too small to be mapped. The various combinations in the mixed rock areas are indicated on the geologic map.

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[41] Miller, William J., Pre-Cambrian and associated rocks near Twenty-nine Palms, California: Geol. Soc. Amer. Bull., vol. 49, pp. 417-446, 1938. See review of other occurrences in this reference.

[42] Hinds, N. E. A., The Jurassic age of the last granitoid intrusives in the Klamath Mountains and Sierra Nevada, California. Am. Jour. Sci., vol. 27, pp. 182-192, 1934.

HYPABYSSAL ROCKS

Lamprophyre Dikes: Lamprophyre dikes are rare. A few of pyroxenic character cut the Sacatar quartz diorite. They were not found in any other formation and thus their age of emplacement is in doubt.

Granodiorite Dikes: Large Isabella granodiorite dikes cut the Sacatar quartz diorite in a number of places. These dikes are commonly in groups, in which they are strikingly parallel to one another. The dikes dip usually at low angles, and may be traced directly into the parent mass with which they connect.

Aplite Dikes: Aplite dikes cut all of the plutonic units and the Kernville series. They are extensively developed in the Isabella. They are found near the contacts of the older rocks, especially the Sacatar quartz diorite, and in cross cutting relations to the Kernville series.

Pegmatite Dikes: A number of large pegmatite dikes occur within the area. They are composed of very pure potash feldspar, and milk-white quartz, with scarcely any other mineral components. Several are large enough to have been opened up for silica. The larger ones are in the Isabella, but smaller and ones of more variable mineralogy occur in the Sacatar quartz diorite. These generally contain the micas and black tourmaline in addition to the typical constituents.

Silexite Dikes and Veins: Silexite dikes occur in a few places, especially where the Isabella is of uniform texture and composition. They usually contain a small percentage of feldspar in addition to the quartz. Some quartz veins were also found.

CENOZOIC VOLCANIC ROCKS

In the southern Sierra Nevada there have been few reported occurrences of volcanic rocks of Cenozoic age. All previously reported are found in the Olancha quadrangle to the north. The volcanic sequences are chiefly olivine andesites and olivine basalts, with some associated quartz basalts, which are scattered over a large area in isolated units, occupying a small areal total. The volcanics all lie north of the South Fork Valley, mainly on the large tableland including the Bartolas Flats and regions to the north and east.

None of the volcanic outcrops exceed 200 feet in thickness; they are separated by erosion from adjacent outcrops of the same type, and are apparently flows which at one time had a larger areal extent. They are definitely of the volcanic period producing flows instead of cones, such as those of the recent volcanic activity in the region immediately to the north, where Knopf [43] describes volcanics that are of apparently Tertiary and Quaternary ages. Those of the Kernville area are probably the time equivalent of the former.

Black, massive, olivine basalts, and gray to reddish olivine andesites are the commonest types. Microscopically they are composed of plagioclase laths, with considerable olivine, often altered to iddingsite; pigeonite, with smaller percentage of magnetite, apatite, titano-augite,

[43] Knopf, Adolph, in Lawson, A. C., *op cit.*, p. 374-76, 1904; also Knopf, *op. cit.*, p. 73, 1918.

and occasional zircon and sphene grains. Eutaxitic structures are common.

ALLUVIAL DEPOSITS

Older Alluvium: Two periods of alluviation are noted in the Kernville area. The older consists of fine- to medium-grained sediments, deposited under shallow-water, lacustrine and fluviatile conditions; and terrestrial deposits laid down in basin-like depressions, particularly on the higher upland platforms. These sediments are exposed by downcutting of streams which flow through them, chiefly in the large upland meadows, such as Big Meadow, Cannell Meadow, and others. The sediments are finely bedded, almost varve-like, with much organic matter, fine silt, and gravelly sands. Alluvial materials along valley bottoms, normal deposits of streams, are in a few cases above the present erosional level and represent trenched stream deposits, probably laid down contemporaneously with the silts and sands of the meadows themselves.

Younger Alluvium: Recent alluvium is found along most of the streams, especially along the Kern River. Alluvium fills the lower stream valleys behind temporary base-levels. A hard-rock zone below Bodfish on the lower Kern has been responsible for extensive alluviation, resulting in a wide, flat-floored valley extending headward and up tributary streams for several miles.

SUMMARY OF DESCRIPTIVE PETROLOGY

The petrologic sequences of the Kernville quadrangle may be summarized as follows: (1) A later Paleozoic (?) (Kernville) series of moderately metamorphosed sedimentary rocks, of marine origin, with a small percentage of metamorphosed volcanic rocks, intruded by (2) a (Summit) gabbro and (3) a (Sacatar) quartz diorite of probably Permo-Carboniferous age (?) followed (4) in Jurassic (?) time by a (Isabella) granitic batholith. (5) Dike rocks of various types intrude all preceding units. (6) Volcanic rocks cap some erosion surfaces. (7) Deposition of alluvium of two sequences.

FAULT FEATURES

Introduction

The major structural feature of the Kernville quadrangle is the Kern Canyon fault. Only two minor faults were noted. Folds are found in the Kernville series, but they do not merit special description.

Kern Canyon Fault[44]

The Kern Canyon fault trends northward approximately half way between the eastern and western margins of the Sierra Nevada block. It roughly parallels the marginal faults on the west, and is, as far as the writers are aware, the largest fault within the southern Sierra Nevada. It is also one of the few long faults within the southern part of the range.

---

[44] Not to be confused with the Kern River fault, which crosses the mouth of the Kern River at the point where it enters the San Joaquin Valley.

See: Blackwelder, Eliot, Scarp at the mouth of Kern River Canyon: (*abst.*), Geol. Soc. Amer. Bull., vol. 38, p. 207, 1927.

The fault is definitely known to extend from Kernville northward at least 40 miles, approximately to the mouth of Golden Trout Creek (see Mount Whitney quadrangle). South of Kernville its continuation is doubtful, as there is only weak physiographic evidence of it. Numerous geomorphic anomalies in the area south of Kernville, which have been described by Lawson[45] and attributed by him to faulting, may lie on the southern continuation of the Kern Canyon fault, although direct evidence of faulting there is lacking. Dr. J. P. Buwalda, of the California Institute of Technology, informed the writer[46] that he and Mr. H. O. Wood attempted to trace the fault southward from Kernville and that no direct evidence was available for its continuation. Mr. F. E. Matthes, of the United States Geologic Survey, who is now studying the Sequoia National Park area, has investigated the presumable continuation north of Golden Trout Creek and says that the influence of the fault is distinctly minor in the geomorphology.[47] This is in accord with the writers' observations that the fault dies out northward.

Evidence for the fault is[48] as follows: (1) the presence of a steep, bold, frayed escarpment as the eastern wall of the Kern Canyon rising 2500 to 3000 feet above the river for a distance of over 15 miles. This has been shown to be a fault-line scarp. (2) Discordance of stream profiles of those tributaries to the Kern which cross the fault line. (3) A line of cols and canyons along the fault line within the canyon of the Kern itself, with resultant trellis drainage patterns. (4) Rock differences adjacent to the fault, particularly contact relations between crystalline units of the granitic batholith and the Kernville series. This relationship is not, however, everywhere present along the fault; in some cases the fault obliquely transgresses the contacts between rock units. (5) Discordance in attitude of the remnants of the Kernville series with the fault. (6) Presence of master joint systems paralleling the fault in many places. (7) Presence of breccias, mylonites, and alteration products along the fault line. (8) Presence of numerous warm springs emerging along the fault zone. (9) Additional activity of solution along the fault line where numerous caverns have been formed by solution of marbles in the Kernville series.

In summary, the Kern Canyon fault is a well-defined, mappable structural feature. It is amply attested by physiographic, structural, and petrologic evidence. It is a very old fault, produced probably during the development of the ancestral Sierra Nevada, whose roots only are now visible, but which, as a line of weakness, offers erosion easy work in sculpturing special land forms. The nature of the movement on the fault is not known.

The Durrwood Fault

A high escarpment west of Sirretta Peak suggests faulting, although not conclusively. Evidence is (1) a high aligned ridge, facing west and rising abruptly from a canyon lineament above the Kern Canyon fault (2) line of canyons and cols eroded along the trace

[45] Lawson, A. C., Geomorphic features of the Middle Kern: *op. cit.*, 1906.
[46] Buwalda, J. P., oral communication.
[47] Matthes, F. E., Oral communication.
[48] The Kern Canyon fault features are more fully covered in a brief paper by Webb, *op. cit.*, 1936.

of the conjectured fault (3) the numerous springs emerging along the lineament (4) joints, parallel and sub-parallel to and along the escarpment.

Sacatar Canyon Fault

A small fault coincides with a line of canyons at the extreme northeastern edge of the area. This fault has little structural and geomorphic significance, in that it is less than half a mile long and appears to have had little influence on the topographic history. Evidence for the fault is (1) a series of small rounded hills hugging the east side of the canyon; these are interpreted as kernbuts, as defined by Lawson[49]; (2) extensive brecciation of the rocks within the kernbuts; (3) mineralization in the kernbuts; (4) sub-parallel joints in the face of hills rising east of the kernbuts, more or less parallel to the trace of the fault.

Summary of Fault Structures

Other than the Kern Canyon fault, structural features are relatively unimportant in the geology of the Kernville quadrangle. Folding occurs in the Kernville series, but there are no impressive folded structures worthy of special description. Joint systems are present, but there is insufficient regularity in them to warrant special descriptions in this paper.

[49] Lawson, A. C., The Geomorphology of the upper Kern Basin: Univ. Calif. Pub., Bull. Dept. Geol., vol. 3, p. 332, 1904.

ILLUSTRATIONS FOR REPORT

By William J. Miller and Robert Webb

DESCRIPTIVE GEOLOGY OF THE KERNVILLE QUADRANGLE, CALIFORNIA

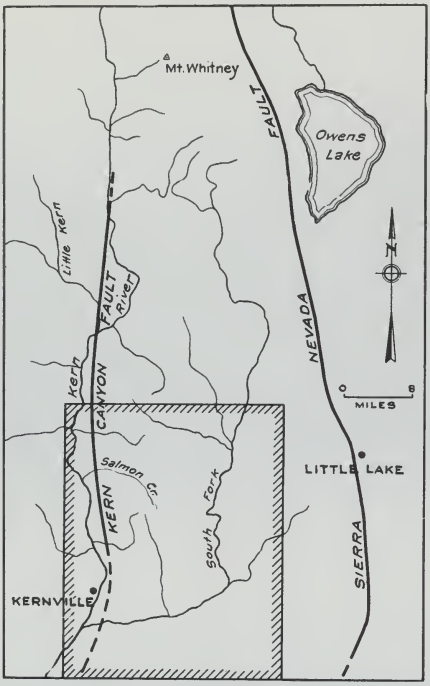


Fig. 1. Sketch map showing location of Kern Canyon fault, in relation to topographic features of the southern Sierra Nevada. Kernville quadrangle is shown with a shaded outline.

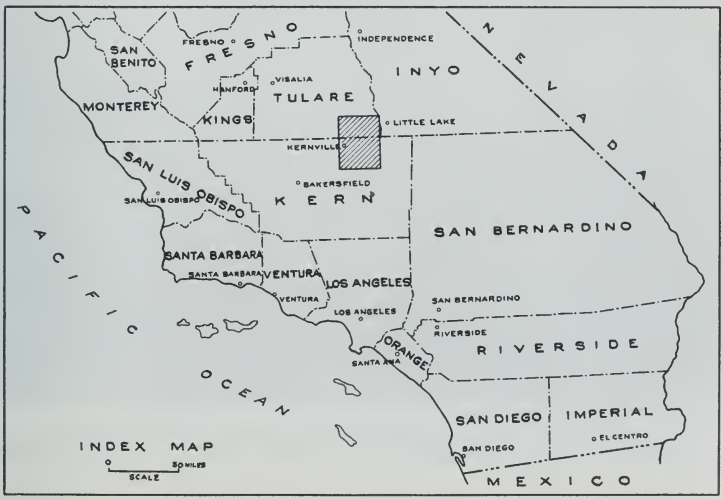


Fig. 2. Index map showing location of the Kernville quadrangle, Southern Sierra Nevada, California.

Fig. 3. General view across the southern Kernville quadrangle, showing the monotony of relief in the flat-topped summits. Kiavah Mountain section is shown.

Fig. 4. General view of the topography of part of the South Fork of the Kern in the northern half of the quadrangle. Flat-floored valleys and broken cross ridges are typical.

FIG. 5. Hot Springs Valley, looking north-northeast across the quadrangle. High upland at head of the valley is the central northern part of the area. Town of Bodfish in lower right.

FIG. 6. Platy phyllite on contact with Isabella granodiorite, two miles east-southeast of Kernville. Sharp contacts along intrusive margins with the Kernville series are commonly the rule.

FIG. 7. View looking across Kernville quadrangle. Dome Land in the middle distance. Flat-topped mesa in middle distance is lava-capped. Lava-cap also seen in middle foreground. Sparse pine and sage covered foreground shows typical soil cover of the Kernville series. Note contrast to baldness of the Isabella granodiorite, forming the Dome Land.

FIG. 8. Looking across one of the upland meadows of the northern part of the quadrangle, showing the domes of the Isabella granodiorite on the margin of the Dome Land.

FIG. 9. Big Meadow, looking south, from rocky ridge across which outlet of meadow is cut.

FIG. 10. Rock-bound outlet of Big Meadow, looking west. Entire drainage of meadow is through this notch.

FIG. 11. General view on the Meadowlands, showing meadow lying below general erosional level of adjacent upland.

FIG. 12. Huge marble outcrops of the Kernville series. Looking north along trace of the Kern Canyon fault.

Fig. 13. Bold outcrop of quartzite, typically seen in the Kernville series. Also shows rounded hillslopes and subdued relief occasioned by weathering of the Kernville series.

Fig. 14. Platy foliation in schists of the Kernville series. Exposure six miles southeast of Kernville.

FIG. 15. Sharp contact of Isabella granodiorite and Kernville undifferentiated metamorphics south of Bodfish in Piute Mountains.

FIG. 16. Parallel system of Isabella granodiorite dikes cutting Sacatar quartz diorite in eastern part of quadrangle, south of Rockhouse Meadow, near contact quartz diorite and granodiorite.

FIG. 17. Dark inclusions of Summit gabbro in Sacatar quartz diorite, in northeastern part of quadrangle, head of Sacatar Canyon.

FIG. 18. Typical aplite dike cutting Sacatar quartz diorite, south of Rockhouse Meadow.

FIG. 19. Great outcrops of Kernville marble southeast of Weldon. Southern part of marble bed shown on geologic map which crosses the South Fork Valley.

FIG. 20. Sheet jointing in the Isabella granodiorite, in the Bartolas Country.

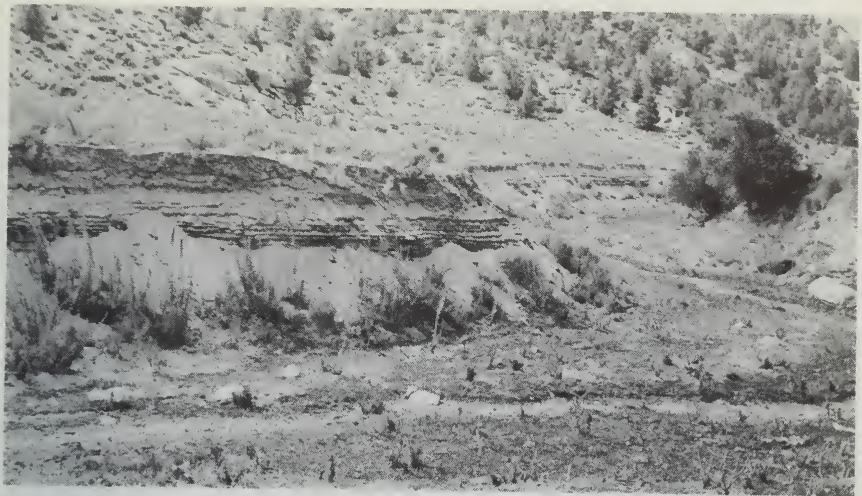


FIG. 21. Section showing silts and finely bedded sands found in the meadows on the central upland of the quadrangle.

FIG. 22. Platy weathering of Isabella granodiorite in the Dome Land.

FIG. 23. Trenched cones and fans along west side of the Kern River south of Fairview. Notice small fold on left in Kernville marble.

FIG. 24. Boulders of weathering, residual upon granitic slopes. Isabella granodiorite bedrock.

Fig. 25. Close-up of lava-capped mesas seen in figure 26. Cap of basalt about 150 feet thick. Bartolas Country.

Fig. 26. Lava-capped mesas in the Bartolas Country, looking west. Parallel dike system vaguely seen in middle distance.

Fig. 27. Large dome on margin of Dome Land, showing exfoliated character. Sediments of a meadow are seen in the foreground.

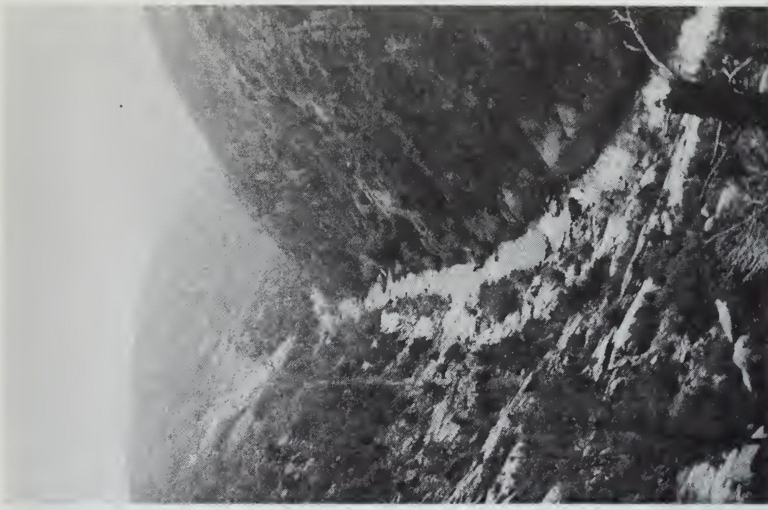


Fig. 28. Gorge of Main Fork of Kern River, looking north, above Fairview. Note flat uplands along west side of river.

Fig. 29. Typical mushroom rock produced by chemical weathering and wind erosion, occasionally found in the Isabella granodiorite of the Dome Land.

Fig. 30. Platy flow structure in quartz-basalt, in the Bartolas Country.

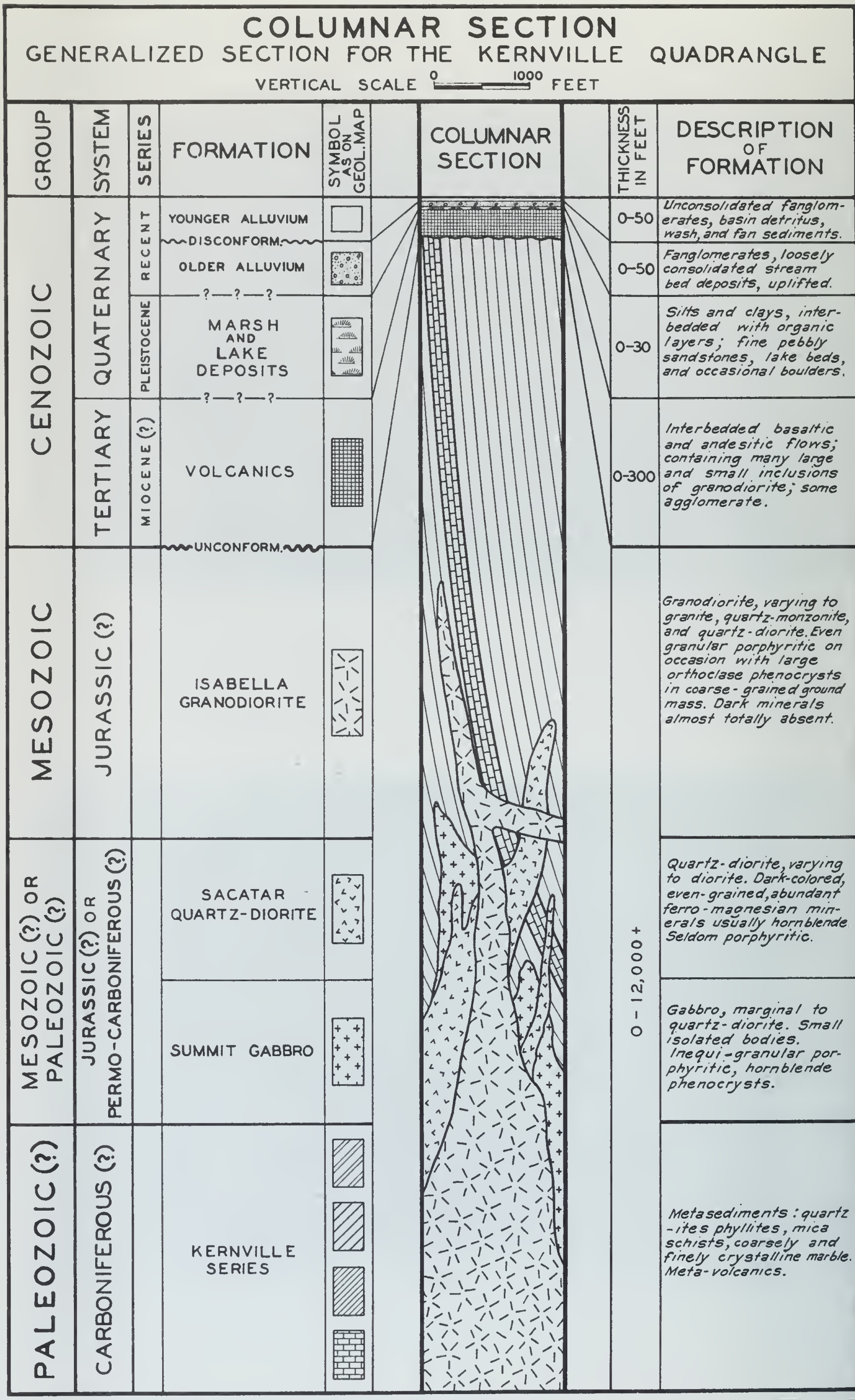


FIG. 31. Columnar section of the Kernville quadrangle.

DIVISION OF MINES
WALTER W. BRADLEY, STATE MINERALOGIST.

STATE OF CALIFORNIA
DEPARTMENT OF NATURAL RESOURCES
RICHARD SACHSE, DIRECTOR.

PLATE II

ACCOMPANYING STATE MINERALOGIST'S REPORT XXXVI OCTOBER 1940.

GEOLOGIC BRANCH, OLAF P. JENKINS, CHIEF GEOLOGIST.

GEOLOGIC MAP OF KERNVILLE QUADRANGLE, CALIFORNIA

BY WILLIAM J. MILLER AND ROBERT W. WEBB

SCALE

0 ½ 1 2 3 4 5 6 MILES

Contour interval 500 feet

GENE
GROUP
CENOZOIC
MESOZOIC
MESOZOIC (?) OR PALEOZOIC (?)
PALEOZOIC (?)

GEOLOGY OF THE BIG BLUE GROUP OF MINES KERNVILLE, CALIFORNIA

By JOHN W. PROUT, JR. *

OUTLINE OF REPORT

* Consulting Mining Engineer-Geologist, Los Angeles, California. Manuscript submitted for publication October 3, 1940.

5—93872

ABSTRACT

The Big Blue group of mines is located about $1\frac{1}{2}$ miles north of Kernville, California, at an elevation of approximately 2800 feet.

The early history began with the finding of placer deposits of gold in 1851. The gold quartz veins were discovered in 1860 and have been historically famous since then. In the early days, until 1883, the mine produced several million dollars worth of gold ore. From 1883 to 1936 the mines were operated periodically with little success. Since 1936 the mines have continuously produced commercially profitable ore.

The oldest rocks on the property are of sedimentary origin and correspond to the Paleozoic Calaveras formation of the northern Sierra Nevada. They consist of schists, quartzites, slates, phyllites, and limestone. Since no fossil evidence has yet been found, the rocks have been classified according to their physical and mineralogical properties, and have been found to compare favorably with other Paleozoic formations in California. These formations taken together must have originally been several thousand feet thick.

The granodiorite and associated rocks which formed the Sierra Nevada batholith were intruded during the close of the Jurassic period. The elevation of the batholith produced faults and deformation of land masses. This event was closely followed by the intrusion of alaskite, aplite, and silexite dikes. A well-defined shear zone was developed which extends the entire length of the property, over 8,000 feet long and as much as 100 feet wide, near the central portion of the planes, and is tightly closed at both ends. This shear zone contains the principal orebodies. Mineralization accompanied and immediately followed the intrusion of aplite and silexite dikes.

In the scale of geological events it is assumed that the granodiorite intrusion occurred during late Jurassic time, and since the alaskite, aplite dikes, and primary ore immediately followed, we can say that the primary ore is post-granodiorite in age, and possibly post-Jurassic.

The description of the intrusive rocks shows the close relationship existing between the alaskite, aplite, silexite, and primary blue quartz of the ore. A detailed study has been made of all formations and all the rock types. Many petrographic sections of all the intrusive rocks have been made and correlated. The alteration products of various minerals have been traced back to their origin. The granodiorite is typical of the Sierra Nevada batholith.

The alaskite dike consists primarily of feldspar and quartz, which by hydrothermal alteration and faulting has not only altered the feldspars but has produced a wavy appearance as seen under the microscope. The contact between the alaskite and granodiorite assumes a gradual change from one rock to the other so that the actual plane of contact is not easily determined in the field.

The unaltered aplite dikes are rather uniform in mineral composition, but in the mine they are so intensely metamorphosed and altered that they are not easy to distinguish from the ore. The silexite dikes are of practically the same composition, but have a bluish tint. On the surface they have the appearance of vein quartz, and can hardly be detected from the true primary blue vein quartz of the ore without a petrographic examination.

The alaskite intruded and cut one of the granodiorite cupolas of the batholith. The compressional forces which assisted in producing the major shear zone also shattered its hanging wall with the result that a system of parallel joint planes was produced. These were later mineralized by solutions of the same character as those that formed the large orebodies in the Big Blue. The intrusive dikes were the products of aqueo-igneous fusion in the magmatic extract, and were conditioned by the joint reactions of heat and water, and the alaskite, aplite, silexite, and quartz of the first stage are considered as differential products.

The expulsion of the mineral-bearing carriers which produced the ore was brought about by the various processes of hydrothermal activity. The mineralizing solutions deposited their burden within the shear zone as ore shoots, and in fractures and seams in the hanging wall. There appears to be a process of pyrometasomatic succession connected with hydrothermal development in the siliceous rocks. The albite, which occurs abundantly in the alaskite and in the shear zone, was produced by the reaction of hydrothermal solutions on the original magma, as replacement phenomena.

The range in temperature of the hydrothermal solutions must have been from hypothermal in the deeper zones, changing to mesothermal in the middle zone, and to epithermal in the upper zone.

The abundance of minerals such as sericite, chlorite, and other alteration products with the sulphides, especially the arsenides, is sufficient evidence to indicate that the type of ore is the result of the combination of the various processes accompanying and associated with hydrothermal activity.

Faulting was more or less continuous over a long period of time. The later stage of mineralization was to a certain extent produced by the faulting following the first stage of deposition within the shear zone, which produced a rearrangement of the ore. A certain amount of metasomatic replacement occurred, which had a tendency to increase the gold value.

The detailed description of the mine workings and the results of milling operations are included with a summary and conclusion at the end of the report.

INTRODUCTION [1]

LOCATION OF THE MINES

The gold mining properties of the Kern Mines Inc., are located in the Cove mining district, Kern County, about 1½ miles north of Kernville in Secs. 28 and 33, T. 25 S., R. 33 E., M.D. The area in which the mines are located is in the hills which border the deeply eroded valley through which flows the Kern River. The banks of this stream are lined with a heavy growth of trees and the valley floor is made up of Quaternary rocks, gravels, and sands. Surrounding the valley are

[1] In submitting to the reader the following report on the economic geology of the gold quartz veins of the Kern Mines Incorporated, located in the Cove mining district near Kernville, California, it is felt that the report would not be complete without referring to the cooperation of many of the individuals, both those in official positions and in other capacities, whose continuous assistance and efforts have greatly expedited the exploration work and proved invaluable in the coordination of operating details. I therefore wish to thank Mr. Roland Tognazzini, President; Dr. W. L. Rogers, Vice President; Mr. Dudley S. Bates, Secretary-Treasurer; Mr. C. S. Long, Jr., Representative of the Lessor; Mr. R. W. Prout and Mr. Fred W. Sherman, of the Engineering Department. The company officials have kindly given their permission for the publication of the report. *John W. Prout, Jr., July 1, 1940.*

the steep, rugged ridges and peaks of the Sierra Nevada, which present a varied and picturesque scene.

The property consists of about 20 mining claims. It includes the historically famous Big Blue, Sumner, Jeff Davis, and Lady Belle mines, together with other mines, mill sites, and certain water rights of the Kern River. The elevation at the mine is about 2,800 feet, and at Kernville about 2,569 feet above sea level. Good oiled roads lead to the property from Bakersfield and Mojave. The Bakersfield route, 53 miles, follows the Kern River through Kern Canyon; the route is longer from Mojave via Freeman Junction and Walker Pass.

Mt. Whitney, of the Sierra Nevada, is the highest peak in the United States proper, reaching an altitude of 14,496 feet. It overlooks Death Valley, 280 feet below sea level. The headwaters of the Kern River are on Mt. Whitney, where abundant water is furnished by glaciers, snow banks, and rain throughout the year. The river, one of the most important in this section of California, flows through Bakersfield and empties into Buena Vista Lake near the head of the San Joaquin Valley. In the season of 1915-1916 the water run-off was about 2,462,800 acre feet, which is considered to be the maximum in recent times. The average minimum season run-off is about 300,000 acre feet.

East of the Big Blue mine, in the foreground, is the Kern River valley; in the distance the peaks of the Sierra Nevada rise to an altitude of nearly 10,000 feet. The Kern Valley averages 1 mile in width and extends from Bodfish, on the south, to the vicinity of Fairview, a distance of 24 miles; upstream, however, at the junction of Bull Run and Cannell Creeks, near the common county line of Kern and Tulare Counties, the valley narrows, and the banks become steeper.

West of the mine, Split Mountain, of the Green Horn range, attains an altitude of 5,823 feet. It is the highest peak near the mine. The mountains on both sides of the valley are rugged and precipitous, and in some areas they are heavily timbered.

HISTORY OF THE REGION

The Kern River valley was supposed to have been inhabited by the Tubatulabal Indian tribe at the time Joseph Walker made his exploration trip into California in 1833 or 1834. His travels took him from the Owens Valley country across the Sierra Nevada divide at Walker Pass. A part of John C. Fremont's expedition entered the San Joaquin Valley by this route in 1845. A Government topographer by the name of Kern was a member of this party, and the river and county were named for him. Many of the famous pioneers and immigrants, including Kit Carson, passed this way in their travels to California in search of the riches of the Golden West.

The influx of miners in the gold rush days of 1849 finally terminated with their entrance into Mariposa County at the southern end of the Mother Lode. Those pioneers who still were lured by gold continued to seek new fields of adventure, and two years later, in 1851, they turned their attention to the Kern. At one time a gold nugget weighing 42 ounces was found about 4 miles below Kernville. This incident was followed by a rush of prospectors which created much excitement and caused a bustle of activity throughout the area.

In 1855 most of the disappointed fortune hunters made their retreat to other places of promise. The placer deposits proved to be limited in extent, but a few parties are reported to have made from $16.00 to $60.00 per day for a short time. The majority, however, failed. Some of the placer mining was done in the Cove district along the banks and bars of the river and along numerous gulches tributary to it, but the work was carried on in a restricted manner because the values were low. The placer discoveries led some of the prospectors to the more encouraging quartz lodes at Whiskey Flat (Kernville), Keysville, and Havilah. Following the advent of the white man, the Chinese reworked the placers.

In the year 1860, Lovely Rogers found his strayed mule near the foot of Split Mountain. On taking a piece of rock from the hillside to throw at the mule, his attention was attracted to gold showing in it. Rogers, by diligent search, found the outcrop from which the specimen came, and so started the final boom, which led to the discovery of the Big Blue mine.

Following the discovery of gold in the Cove mining district, the town of Quartzburg sprang up adjacent to the mine on Cove Flat on the west bank of the river, an ideal location for a town. Quartzburg flourished for a time as the principal mining camp, but because of the many brawls and disorders the saloon portion of the town was moved down the river 1½ miles to the present site of Kernville, at which place a bartender offered his wares for sale over a counter made of a board resting on two kegs. This is the location of the present main street of Kernville. Quartzburg finally fell in ruins, and the only remains to be seen today are a few foundations and chimneys of houses.

By mutual consent and agreement of the residents of the two towns, the graveyard was located half way between Kernville and Quartzburg, and like most of our frontier towns of the early days, it contains the remains of those who died with their boots on.

It is said that some fifty Frenchmen operated arrastras and Chilean mills for the extraction of the gold, and that these mills were the first quartz mills introduced on the Pacific Coast. These accomplishments indicate the sturdy pioneering spirit of the men of those days, when the mode of transportation was confined to wagon, ox team, or mule back. The machinery that was used later in the mines was brought from San Francisco and other places on the Coast by wagons, and was carried over the Green Horn mountain trail on mule back. This feat required almost superhuman effort on the part of fearless men.

As time passed, quartz mills began to be erected, the veins became richer, a more stable mining program was established, and a more hopeful future was visualized. Traffic in people and goods was promoted and many settlements sprang up. Havilah became the center of activity and was the first County Seat of Kern County. With the expansion of mining, agriculture, irrigation, and railroading, however, the County Seat was moved to Bakersfield, in 1874.

The romantic history of the Kern Mines, Inc., has been long and varied. At one period during the late seventies and early eighties the mine was successfully operated and the ores were treated by stamp milling—amalgamation processes. The records are incomplete and vague and do not report the amount of gold produced from the prop-

erty in the past. A plausible guess, however, would be that the total value of production amounted to several million dollars. Old reports show that the losses in milling must have amounted to 40 or 50 percent of the gold contained in the original ore, especially below the oxidized zone. After the early eighties, the mines apparently were not operated with any degree of success, for many reasons. One reason was certainly the failure of operators to interpret correctly the geological conditions which would enable them to find the ore at depth, and another was the lack of money for development work.

Rossiter W. Raymond in 1875-1876, reporting in the Seventh Annual Report of the United States Commissioners of Mining Statistics, said in part:

> "The old 16 stamp mill is said to have carried from $100,000 to $300,000 profits, which have been swallowed up in purchases, improvements and litigation. * * * The Quartz is bluish and charged with arsenical pyrites. * * * The value of the main lode lies in its great size * * * principal mine is the Sumner * * * and the lode 80 feet between walls. * * * The hanging wall is granite and the foot wall slate. * * * The average yield of the whole material is about $18.00 per ton."

Unfortunately the fire of 1883, which destroyed the Sumner shaft, underground timbering, and mine surface buildings, completely wrecked the property, so much so that for many years following the fire, mining was carried on only by tributers (lessees).

The first vein mining was evidently done by Lovely Rogers. From the time of his discovery of gold ore in 1860-1861 until the early seventies, the mines were worked and owned as a number of separate properties. Judge J. W. Sumner consolidated some of the mining property and produced a substantial amount of gold.

Senator John P. Jones, the Bonanza King from Nevada and the famous Comstock, in 1875-1876 consolidated all the mining and water rights, forming what was known as the Sumner Gold and Silver Mining Company. The property continued under this ownership until April, 1881. During this period two stamp mills of 16 and 80 stamps respectively were built and successfully operated for two years, and spasmodically thereafter for a short time. The power was furnished by a 54-inch water turbine. The water to run the turbine was carried from the river by a ditch about $1\frac{1}{4}$ miles long. The surface equipment consisted of a system of surface tramways leading from the Pioneer and North tunnels to the 80-stamp mill located on the river. Foundries, shops, the large "white house" dwelling, and mining equipment were erected. The water from the Sumner shaft was pumped by a walking beam pump through 16-inch and 12-inch water column pipe. This company also operated a reverberatory furnace to roast concentrates made by Hendy concentrators.

After 1881 the mines were leased and operated by the firm of Michaels, Freidlander and Company until an incendiary fire in 1883 completely burned and destroyed the Sumner shaft, surface buildings and equipment, the loss amounting to $250,000.00. The fire swept through the entire mine and smouldered for many years. This caused the ground to cave in, rendering the mine unworkable. The remaining buildings were allowed to fall into decay.

In 1907 the Kern Development Company acquired the property. The water-power ditch was reconstructed, a new water turbine and

penstock installed, the 2,000-foot tunnel reopened, the Donkey shaft reconstructed and renamed the Cove shaft.

I have been given the following information by Mr. C. S. Long, Jr.:

"From 1907 to 1926 the Kern Development Company leased portions of the property on numerous occasions but apparently none of these operations developed any considerable tonnage of commercial ore. In 1927 Mr. Jubien of New York leased the Big Blue, Sumner, Content, and Nellie Dent mines. Diamond drilling and drifting were carried on from the 260 level. This lease was abandoned and no ore extracted.

"The American Smelting and Refining Company leased these same mines in October of 1931 and carried on an extensive exploration program. This work consisted of drifting south on the 260 level, the sinking of a 158-foot winze and drifting both north and south on the 400 level. The A. S. & R. relinquished its lease in September 1932.

"In 1934 Mr. A. V. Udell organized a group which later became the Big Blue Mining Company. A more modern mill was constructed and extensive development work was carried on until April 1935 when the company was forced to seek reorganization under Section 77B of the Federal Bankruptcy Act. Kern Mines Inc. bought out the Big Blue Company under supervision of the Federal Court and has been in possession of the properties ever since."

The fact that a substantial production of gold ore was made from the mines prior to the destructive fire of 1883 was evidence that they had merit. For over 53 years since, until the midsummer of 1936, all efforts to restore the mine to its former productiveness failed. The writer became associated with the Kern Mines Inc. in May 1936, and found it necessary, before planning new development work, to make a thorough study of the geology, in order to classify the ore deposits and to solve the fault problems, without regard to previous undertakings. The results of these interpretations have placed the Kern mine, one of the historical mines of California, on a profitable working basis.

GEOLOGY

In the following discussion I will endeavor to present a review of the major geological events controlling the rock formations, the structural features, and genesis of the ore deposits.

GEOLOGICAL FORMATIONS AND SEQUENCE

Sedimentary Rocks

Cenozoic
- Quaternary
  - Younger alluvium: stream deposits of recent origin.
  - Older alluvium: stream deposits of earlier origin.

Mesozoic
- Cretaceous, Jurassic, Triassic } To date no evidence found.

Paleozoic
- Carboniferous
  - Calaveras formation: schists, quartzites, slates, phyllites, limestone highly metamorphosed and altered. Folded, faulted and elevated by mountain-building system of the Sierra Nevada. On the property, small isolated blocks are found inclosed in the igneous rocks. They are of marine origin with no fossil evidence, but correlated physically with the Calaveras formation of other California provinces.

Igneous Rocks

(Listed with oldest intrusion first)

Granodiorite: probably intruded at close of Jurassic period and relatively the same age as the granodiorite of the Sierra Nevada. Followed by intense faulting.

Alaskite dike: intruding granodiorite and older formations; immediately followed by the intrusion of the aplite and silexite dikes.

Aplite
Silexite } dikes: intrude alaskite, granodiorite, and older formations.

Ore: accompanied and followed the intrusion of the alaskite, aplite, and silexite dikes.

Since the alaskite, aplite, and silexite dikes, accompanied by mineralization, immediately followed the last stage of the granodiorite batholith, they are considered to be post-Jurassic.

The intrusion of the granodiorite batholith of the Sierra Nevada partly relieved the compressional forces, but was not sufficient to compensate all the stress, for on the property compressional jointing and faulting are found. The movements continued active long after the advent of the intrusion. All stress planes and folding of the superimposed formations are not necessarily parallel to the axis of the range, but they are normal to the direction of stress in this region.

The veins are located at one of the cupolas. The quartz-feldspar, alaskite, and related rocks were forced upward through the fracturing of the hood. They were followed by the metalliferous fluids. Some of the zoned ore formed at this time, accompanied by contact metamorphic action. This period was followed by later fracturing and a second period of metalliferous deposition.

It has been found in areas of regional disturbances of great magnitude wherein batholiths played one of the principal roles in producing large masses of rock, that during their intrusion they were accompanied by much faulting and displacement; also, that many batholiths have a volume of several cubic miles, as in the case of the granodiorite batholiths and related rocks in the Kernville area. These rocks are a part of the Sierra Nevada series of rocks. It can be assumed that this magma contained at least 1 percent water in solution, so a cubic mile of the batholith could easily contain several million tons of water, which in the original magmatic condition would influence, to some extent, the amount and rate of crystallization of the various minerals of which the batholiths are composed. The water also assisted in supplying solutions for the migration, transportation, and deposition of the metallic minerals and quartz found in these mineral deposits.

In sections of California the graphic granitic complex of the pegmatitic and other rocks of this class may not represent the original formation, because there is a decided sequence in the crystallization of the minerals. Much of the coarser perthitic albite must be considered the result of secondary reaction. We have albite replacements of microcline with individual shafts or rods of quartz defined largely by the original potassium feldspar but formed later than the feldspar. Hydrothermal activity on the property produced replacement reactions essential to the development of the albite and quartz.

The cooling processes formed shells of various thicknesses of rock, grading from true leucocratic rocks to those whose minerals showed various degrees and stages of development. This condition was followed by the intrusion and injection of acidic dikes, alaskite, aplite, and silexite which have a direct correlation with ore deposition. There are other related rock types, such as gabbro, lamprophyre, and pegmatites, in the Kernville quadrangle. Some of these are considered to be the direct injecta into fissures, and others are decidedly differential

products. The structure of the Kernville area is the result of regional disturbance due to deformation of land masses by uplift, igneous intrusions, and faults.

Prior to the Sierra Nevada uplift, Paleozoic seas invaded the area and Paleozoic sediments were deposited. It is my opinion that these formations correlate physically and mineralogically with those Paleozoic formations found in other California provinces. These rocks on the property consist principally of quartzites, slates, phyllites, schists, and in some cases limestone; all are tilted at various angles and have no general strike. The deformation was a result of the folding, faulting, and elevation produced by the granodiorite batholith and later intrusions, accompanied by land readjustments.

If some of the sediments belong to the Jurassic-Triassic periods of the Mesozoic, the evidence so far found does not corroborate the fact. There has been and still is considerable discussion as to the age of these particular sedimentary formations. I am convinced by the field evidence so far found, that some of these formations are certainly older than Mesozoic, and are probably Paleozoic. These sediments were deposited in the great Paleozoic geosyncline which crossed California from the Pacific to Nevada.

INTRUSIVE ROCKS

Granodiorite. The oldest of the intrusive rocks exposed on the property is classified as granodiorite, and is probably the same age as the batholith of the Sierra Nevada—either late Jurassic or early Cretaceous. It is a wholly crystalline rock consisting of orthoclase, albite, plagioclase, biotite, and hornblende, with some few accessory minerals, and it extends in a circular outcrop on the west side of the mineralized shear zone to and including Split Mountain. It is faulted by the shear zone near the Cove shaft. The main portion on the east side of the shear zone extends westerly from the vicinity of the present mill to the contact with the sediments on the east side of the shear zone. It then extends south along the river. The granodiorite shows the least amount of alteration of all the surface rocks.

Alaskite. Alaskite is a holocrystalline rock of visible and rather even grain, leucocratic, with orthoclase, albite, plagioclase, and quartz predominant. The feldspars are altered and they, along with the quartz, average 1/10 of an inch or more in diameter. The rock is light colored, stained slightly yellow by the weathering and decomposition of feldspars. Erosion has left the quartz nodules protruding, making a rough surface. All minerals present show a foliated and wavy appearance, due to movement. The wavy appearance is distinctly visible under the microscope, particularly around the feldspars. The alaskite intrudes the sediments and granodiorite.

The rock has been named alaskite principally from its field appearance, with quartz and feldspar the predominant minerals. On the surface it has a very jagged, rough, pendant-like appearance. The feldspars are partly sericitized. Practically all the minerals are fractured and broken apart, and recemented with later quartz, showing much strain and pressure.

Aplite. The aplite is light colored, almost white, fine-grained, and sugary textured. It has practically the same composition as the alaskite, and occurs as dikes generally 2 to 4 feet wide, but sometimes wider. It is intrusive into all formations, and was formed immediately after the alaskite, which it cuts. The aplite was followed by the intrusion of silexite, a very fine-textured, bluish-colored, siliceous rock. It has a conchoidal fracture, and can easily be mistaken for vein quartz. The aplite is usually light colored and granular and shows abundant quartz and feldspar of quick-cooling magmatic extract. It is of xenomorphic texture, has a mineral composition corresponding to that of alaskite, but is aphanitic. In some places it has innumerable grains of sulphides.

Both potash and soda-lime feldspars in the alaskite show graphic and myrmekitic intergrowth. The graphic texture was caused by eutectic intergrowth. The quartz shows anhedral form determined by the surrounding feldspars, and is allotriomorphic.

Aplite, like pegmatite, is formed as a result of the expulsion of the residual magma during the late stage of crystallization where alkali feldspar and quartz are forming in the original magma. Quartz is also a late mineral extract, which accounts for the vein quartz and for the aplite dikes. The phase relationship of calcium-sodium feldspar shows clearly why sodium should be concentrated in the late residuum of a crystallizing magma. Pegmatite consists of microcline and (or) quartz, and ordinarily it does not contain any quantity of other minerals.

Potassium feldspar is normally a late mineral in the course of crystallization in the igneous rocks, but later albite rims this feldspar so that myrmekite or albite micrographic granite may develop. These processes belong to a very late or even a deuteric stage of crystallization. The myrmekite or brain-coral texture may be formed in some cases after the consolidation of the rocks, as replacement phenomenon, and this graphic texture is due to eutectic intergrowth.

The aplite dikes have various widths and strikes and intrude all formations. They are injected into fractures and follow various fault planes. For example near the north tunnel where the aplite is faulted and displaced about 40 feet, the dike follows the fracture and cleavage planes southerly in the alaskite. It strikes S. 25° W. and dips about 76° W. North of the fault the aplite continues 600 feet where it is again displaced by a N. 70° E. fault. An aplite dike near the Cove shaft strikes about N. 40° E., and dips 63° W., and intrudes the alaskite on the west wall of the shear zone. The dike is faulted west by the same fault that is near the contact between the alaskite and granodiorite. The aplite, which is prominently exposed at the Cove shaft, continues south within the shear zone and was intruded just before, or at the same time mineralization commenced; but it was subsequently faulted, after the first and second stages of mineralization. There are numerous small dikes of aplite on the property, and I have found that those within the alaskite are associated with mineralization. Where they intrude the sediments outside the shear zone the mineralization is much decreased and no commercial deposits are known to exist.

A petrographic study shows the aplite to be composed of quartz and various feldspars. Much sericitization is in evidence and some dikes of aplite and silexite contain a few crystals of molybdenite.

SURFACE GEOLOGY

The Kern River debouches into the San Joaquin Valley after leaving the mouth of Kern Canyon. At this place, at an altitude of about 1,000 feet, the escarpment of the ''power house fault'' crosses the canyon and defines the boundary line between the sedimentary and granitic rocks. The fault dips westerly at 60° and strikes N. 55° W. The sedimentary rocks form the San Joaquin Valley floor, while the granitic rocks form the basement complex of the mountain region extending easterly from the fault over the summit of the Sierra Nevada to the west side of Owens Valley.

The granodiorite complex found at Isabella and Kernville is part of the batholith of the southern Sierras and is later than the sedimentary rocks of the immediate area.

Near the property the granodiorite extends in a northerly direction along the west bank of the river from Kernville to the mill. It is about 1,200 feet wide. The entire distance of the west flank is in contact with the schists, slates, and quartzites. North of the mill both flanks are in contact with the sediments. The sedimentary rocks on the east side along the mill ditch strike N. 10° to 20° W. and dip 90°, exposing a wedge-shaped block of granodiorite. The sedimentary rocks extend from the west contact of the granodiorite to the east side of the alaskite with an average thickness of about 400 feet. These contacts are very irregular and follow the general ragged outline of the intrusive alaskite.

The elevation of the batholith, accompanied by faulting, was followed by the intrusion of the alaskite along planes of weakness. On the west side of the Big Blue the faulting has displaced the alaskite to the south some 2000 feet from its original position near the North Extension Sumner claim. The alaskite forms the hanging wall or west side of the shear zone; it has a maximum width of about 1200 feet on the surface, and a length of about 2000 feet. The south end is terminated by a fault near the end line of the Blue Gouge and Content claims.

On the west side of the shear zone the alaskite-granodiorite contact strikes westerly from near the Cove shaft to about the middle of the Jeff Davis claim, then crosses the Jeff Davis, Bull Run, and Frank claims. It curves around the southwest corner of the Beauregard claim, crosses the Lady Belle, and continues about 1300 feet to the ridge south of the Lady Belle claim, where it is terminated by the fault which placed the sediments against the granodiorite. Here the alaskite has an included block of sediments inclosed in a re-entrant angle. The sedimentary block forms a small syncline with flanks dipping 35° to 55° on each side. It then extends southerly on the Orejana claim to the end line of the Content and Big Blue claims. These sediments are a part of the large block extending in a westerly direction 2½ to 3 miles from the property. This small area of sediments on the Orejana claim west of the Big Blue is intruded by an aplite dike.

The alaskite forms the footwall of the shear zone for the entire length of the property, beginning at a narrow point on the northeast corner of the North Extension Sumner, and widens toward the south, so that at the south end of the claims it has a width of at least 1800 feet. The east side of the alaskite is in contact with granodiorite, schists, shales, quartzites, and phyllites. These latter have an average width of 400 or 500 feet. They do not extend as deep as the Drainage tunnel and therefore have a shallow depth at this place.

The granodiorite forms the hanging wall of the shear zone almost the length of the Content claim, more than 2500 feet. The sediments form the west side of the granodiorite as a result of movement along a N. 12° E. fault, the west side of which moved south. The shear zone closes on the Nellie Dent claim, and the granodiorite forms the hanging wall in juxtaposition with the alaskite footwall. The whole pattern of the surface rocks is irregular as might be expected in the region of uplift and faulting in which the orebodies occur.

The aplite dikes generally were intruded along the shear zone, not only within it as a mineralizer, but in both walls. The most prominent exposures are on the Big Blue and Sumner claims. Sometimes they follow cleavage and joint planes, and in other cases they cut the formations transversely. The total depth of erosion after the mountain-building epoch is estimated to have been several thousand feet. This information assists in estimating the probable depth where the ore commenced to form.

SEDIMENTARY AND METAMORPHIC ROCKS

Sedimentary rocks of the region are folded, faulted, and crushed, as a result of many displacements. They have different strikes varying from northeast to northwest. For example, near the north end of North Extension Sumner the strike is N. 15° W.; on the south side of the Sumner gulch the strike is N. 30° E. and the strike of the granodiorite is N. 15° to 20° E. In the Big Blue gulch the strike is N. 45° E. with a dip easterly of 35°, while near the Grave Yard or South tunnel the strike is nearly north and south and the dip almost vertical with quartzite in contact with diorite, the course of which is N. 35° E.

Some of the sediments are found completely overturned with large blocks severed from others, pushed up by the alaskite and actually floated by the viscous melt. The original total thickness of these formations was estimated to have been several thousand feet. On the west side of the shear zone the granodiorite forms the hanging wall and extends from the north end of the North Extension Sumner claim to the Cove shaft where it contacts the alaskite.

The sediments near the northwest corner of the Content claim have been displaced by a fault striking northwest, whose south side has moved easterly about 400 feet.

Schist. The schists are micaceous, containing quartz, feldspar and other minerals. On the property the schists range from a few feet to 100 feet in width, and grade into phyllites.

Phyllite. The phyllites are slaty, thin, parallel-plated, foliated—usually dark gray to black, in thin sections very dark brown, fine-

grained, and mostly composed of argillaceous material with some small angular grains of quartz and feldspar. In some places they have a smooth cleavage and grade into a slate. In the field it is difficult to differentiate between the two rocks, although the slates are almost black and perhaps finer grained. For all practical purposes, so far as ore deposition is concerned, they may be classed synonymously with each other.

Quartzite. The quartzites are made up of rather thin-bedded grains of moderate size, rounded and angular, cemented with semi-opaque material like chalcedony, botryodial, cryptocrystalline, with some feldspar crystals very hard and highly metamorphosed, usually light yellowish colored, interbedded with phyllites. As exposed in the Big Blue gulch the quartzites are stained by surface solutions. They are outstanding in their outcrops because they are less susceptible to erosion than the other sedimentary rocks. Other strata are interbedded with sediments and therefore are of the same geological age. The quartzites are perhaps older than the phyllites and younger than the schists, and probably belong in age to the Calaveras of the Carboniferous.

Limestone. All the limestone is recrystallized, some is marbleized, and sometimes it is found thin-bedded and in isolated blocks near the property. In one area southwest of the Big Blue the limestone is thin-bedded, with different layers of the stratum a fraction of an inch thick. The formations probably correlate with the Calaveras of the Carboniferous.

FAULTS

The surface geologic map shows the distribution and relationship of the surface formations. The invasion of the granodiorite batholith, relieved the compressional forces and stresses. Overthrusting produced compressional joining and compound faulting.

The area is greatly faulted, with displacements of considerable magnitude in the vicinity of the Kern River and on the property of the Kern Mines, Inc. The faults are the result of compressional and dynamic forces and belong to one of the main systems of disturbance. A well-defined shear zone begins at Kern River on the north, passes through the entire length of the property and continues south. It is more or less parallel to the Kern River fault, which follows in a general direction the waters of the Kern River from Isabella to Fairview, a distance of about 20 miles.

MINERALIZATION

VEIN SYSTEMS

Gold was originally obtained from placer and lode deposits. In recent years practically all the gold is derived from lode mining, although there were long dormant periods when no work was done and no production made. The placers have been referred to previously, and have long since been abandoned.

The principal gold quartz veins are discussed, and their relation to the different rock formations. Their origin, classification, and characteristics are outstanding from a genetic viewpoint. They have steep dips of over 65°, but are seldom vertical.

There are two main vein systems. The first and most important is the Big Blue, located on the Big Blue and Sumner claims. The second comprises the Lady Belle-Jeff Davis group, which forms a parallel system in joint planes in the hanging wall of the Big Blue. They make acute angles with the Big Blue, have a general strike N. 69° E., and dip in a northerly direction.

The assay values of the ore are irregular and erratic, varying from low grade material of $1.50 per ton to streaks of high-grade assaying $100.00 and more per ton. The average value of ore mined ranges from $5.00 to $12.00. By using the shrinkage system of stoping and by mixing the ore, a fairly uniform value of mill heads is maintained.

It has been previously stated that the major shear zone is due primarily to compression forces acting from the west, and to dynamic forces which are the result of uplift, both prior and subsequent to the alaskite intrusion. In general the shear zone is parallel to other faults that produced the main regional disturbance at the close of the batholithic intrusion. The general strike of the fault planes is north, indicating a close connection with the movements of the fault blocks which formed the main structural features of the range. Many different movements along these major faults have been repeated and they have continued to some extent to the present time. This means that in certain cases faults have remained active for a long geological period. Many readjustments took place along the shear zone before and after the mineral deposition.

The sheared and faulted zone known as the Big Blue, extends through the North Extension Sumner, Sumner, Big Blue, Content and Nellie Dent claims for 8,400 feet and continues south, striking in the general direction N. 32° E. and dipping 72° to the west. The shear zone is the fault in which the movement has been spread over a width of approximately 100 feet. As a result, there is a network of innumerable minor fault planes. Movements of these minor faults were in many directions, and caused a weakening of the rock structure in the zone. Normal, rotational and overthrust faults produced a complex rearrangement of the orebodies and formations.

Shearing and faulting occurred on a large scale. Forces were of such magnitude that the rocks were crushed and brecciated by the cumulative results of movement along many parallel and intersecting planes. The tremendous pressure exerted by both dynamic and compressional forces produced sheeted masses, schistosity, cleavage, and other complications. A heavy clay gouge containing many rounded pebbles composed mostly of alaskite is found on the footwall as a result of extensive post-mineral faulting.

The zone represents a general line of weakness formed originally by the intrusion of the alaskite and aplite. It is one of the main fault zones on the west side of the Kern River, is the same age, geologically, as the Kern River fault, and is a compensating member of it.

The Big Blue vein system is located in the shear zone. On the surface it averages 100 feet in width on the Big Blue and Sumner claims, where the principal orebodies are located. The average dip of the walls is about 72° west.

On each side of this main shear zone innumerable transverse faults and fractures, a number of which strike N. 69° E. and dip at lower

angles, usually dip northerly about 65°, representing movements along compressional joints. The major fracture joint planes formed a parallel system of veins at about the same time the shear zone movements took place. Subsequent movements in the shear zone displaced these planes laterally. They do not now join continuously from one side of the shear zone to the other because of this. Those on the west side are parallel and form the Jeff Davis, Bull Run, Lady Belle, Frank, Urbana and Beauregard veins; all of these had commercial ore to certain depths. This depth depends upon the tightness of the fissure and proximity to the source of mineralization. The resultant of all the acting forces which produced the major disturbance and caused the greatest amount of complex faulting is located near the center of the Sumner claim.

One oblique fault of major importance in the Sumner gulch strikes N. 57° W., dips 90° and is terminated at the shear zone. The horizontal displacement is about 40 feet and the north side of the fault moved west. It intersects a fault striking N. 69° E. in the Big Blue gulch.

The shear zone was faulted and displaced by later movements in the zone. An important post-mineral fault crosses the shear zone diagonally. It begins at the hanging wall near the end line of the North Extension Sumner claim, strikes S. 19° W. and meets the foot wall at the northeast corner of the Big Blue claim; it then extends south parallel with the foot wall. The shear zone tightens at both ends of the property. In addition to faults previously mentioned within its boundaries, there are numerous flat faults which define the limits of certain blocks of ground and which have permitted these blocks to be forced out of place, one block over another. In this way many openings were formed, making possible the easy egress of the mineralizing solutions.

The shearing and premineral faulting allowed large, superimposed blocks of the sediments to be dragged into the shear zone. These formations are found as isolated blocks having various strikes and dips, but usually they are oriented north and south.

At the same time numerous fractures and fissures occurred in the alaskite, all of which formed a more or less parallel system and made other places of egress for the hydrothermal solutions to migrate through the alaskite and deposit their burden of vein material. This deposition followed immediately the mineralization of the mass inclosed within the walls of the shear zone. The principal orebodies were deposited as ore shoots and the solutions which formed migrated to the far reaches of the alaskite, mineralizing it in the joint planes as much as 40 feet and more from the main channel. The feldspars in many cases were replaced and the original vein quartz recemented by the same solution. Fragments of vein breccia found in the second quartz stage indicate that during the first stage of mineralization within the shear zone there was produced a banded type of ore.

The main veinlets leading from the vein proper to the alaskite would indicate a varied rate of deposition over a rather long period of time and suggest that deposition was produced by an intermittent pulsating solution likened to a surging of colloidal material from which the vapor had previously been released by the lowering of temperature and pressure.

The vein quartz filling followed the intrusion of the alaskite at about the time of the injection of aplite. This epoch was accompanied by the intrusion of the silexite. The siliceous mineral contents of all of these were derived from the same source.

Where blocks of the sedimentary formations are found in the main mineral zone, the gold and vein material was deposited around them, but ordinarily the blocks are seldom mineralized enough to make ore. There are cases, however, where the shattering was sufficient to make them pervious to mineralization. Mineralized veinlets penetrate into the alaskite and are filled with angular fragments of quartz and feldspar, arsenopyrite, pyrite, some galena, sphalerite, and gold and silver, the same minerals which are found in the main orebodies.

The accompanying geologic map of part of the new workings on the 360 level typically represents and serves to illustrate the underground geology. The alaskite forms both the foot and hanging walls of the shear zone. Along the foot wall of this zone occurred pre-mineral and post-mineral movements due to faulting. The compensating members of these faults occurred near the hanging wall and within the shear zone, and formed a parallel system.

The hanging wall fault strikes N. 39° E. and dips westerly 72°, and is accompanied by a blue gouge. This gouge was formed by the latest major fault movement. The fault on the foot wall strikes N. 35° E. and dips 72° west. It produced a kaolin-clay gouge 4 feet to 6 feet wide which contains rounded pebbles of alaskite. The two major faults converge as they continue to the north.

Within the shear zone are numerous parallel faults which strike N. 65° to 70° E. and dip 65° to 85° north. They are intersected by a second system of fractures whose strike is N. 25° W. Some of these fault planes which strike N. 65° to 70° E. were at one time a continuation of the compressional joint planes found in the hanging wall forming the Lady Belle system of veins; others are due to the shifting of included blocks of rock within the shear zone as a result of movement. The application of the forces produced a rearrangement of the included blocks. As these were readjusted other fractures occurred at right angles to their face and horizontal planes bound the blocks vertically. During the shifting and rearranging of the blocks their corners and edges were shattered and broken, producing open channels through which solutions could migrate and deposit ore. An aplite dike is displaced by these faults. Near the center of the north end of the Sumner claim a post-mineral fault to which reference has previously been made, crosses the shear zone and strikes S. 19° W., joining the foot wall opposite the Sumner shaft and then following the foot wall. This faulting produced displacement of considerable magnitude in the formations and accounts for the excess of clay gouge found on the foot wall.

Notations on the map indicate the location of the ore and different formations. Three sections of commercial orebodies are indicated by dots on the drawing. One aplite dike is in the No. 1 orebody, another dike is associated with the No. 2 and No. 3 orebodies. The lines marked by capital letters are pre-mineral fault planes, those marked by small letters post-mineral. Where both letters appear together, as A a, faulting was both pre-mineral and post-mineral.

ILLUSTRATIONS FOR REPORT

By John W. Prout, Jr.

GEOLOGY OF THE BIG BLUE GROUP OF MINES KERNVILLE, CALIFORNIA

Fig. 1. Index map showing the position of the Cove mining district, Kernville quadrangle, and trails of the early explorers.

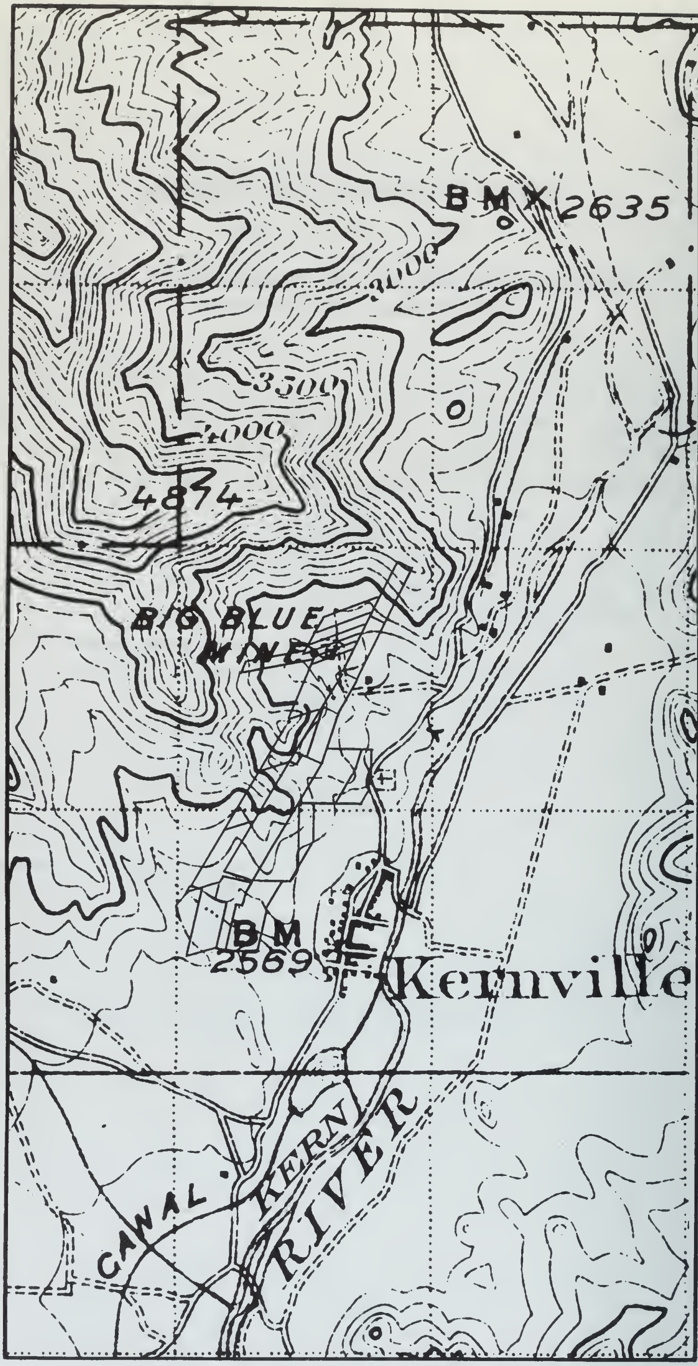


FIG. 2. Topographic map—a portion of the U. S. Geological Survey Kernville quadrangle—showing claims of the Big Blue mine.

FIG. 3. View of the Kern River valley from Greenhorn Mountains.

FIG. 4. View of Kern River valley and the Sierra Nevada.

FIG. 5. View of hills on the property of Kern Mines, Inc.

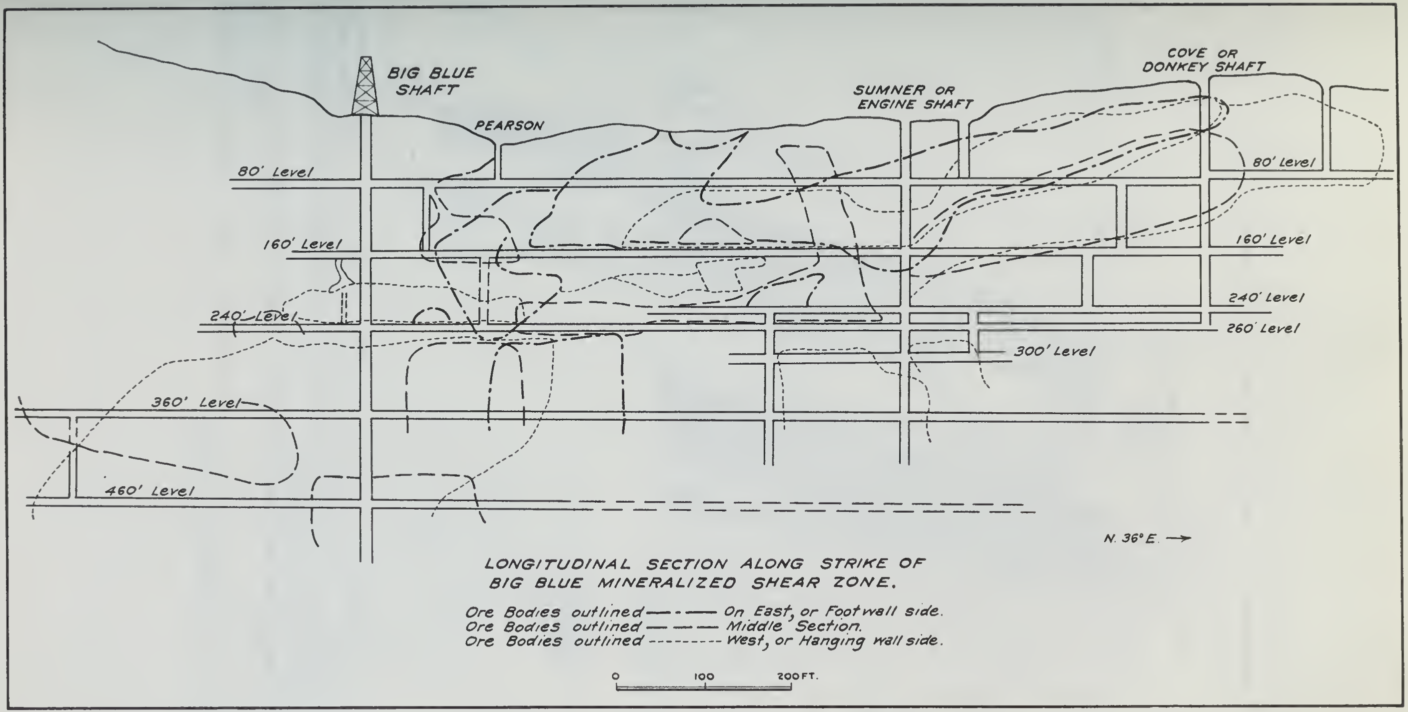


FIG. 6. Longitudinal section along strike of Big Blue mineralized shear zone, showing approximate outline of various orebodies within the walls of the shear zone. Each orebody has been faulted and displaced. This movement partially accounts for the overlapping appearance of the ore.

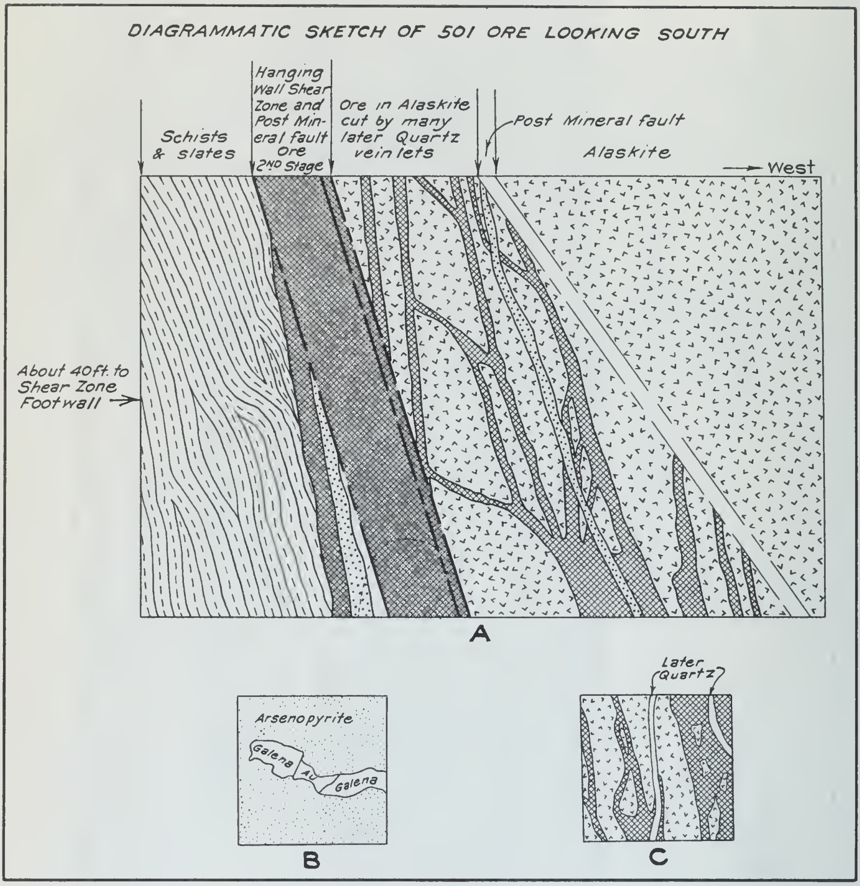


Fig. 7 A. Diagrammatic sketch of 501 ore looking south. Shows cross-section, representing width of about 60 feet. On left side, schist and slate irregularities are due to movement. Ore occurs with aplite dike adjacent to post-mineral fault zone, which contains ore of second quartz stage. The hanging wall is alaskite ore and is limited by post-mineral fault.

B. Microscopic study of grain of early arsenopyrite replaced in part by later gold and galena. x250.

C. Sketch of alaskite ore showing later quartz veinlets cutting ore, sulphide, and early quartz; all replace the alaskite.

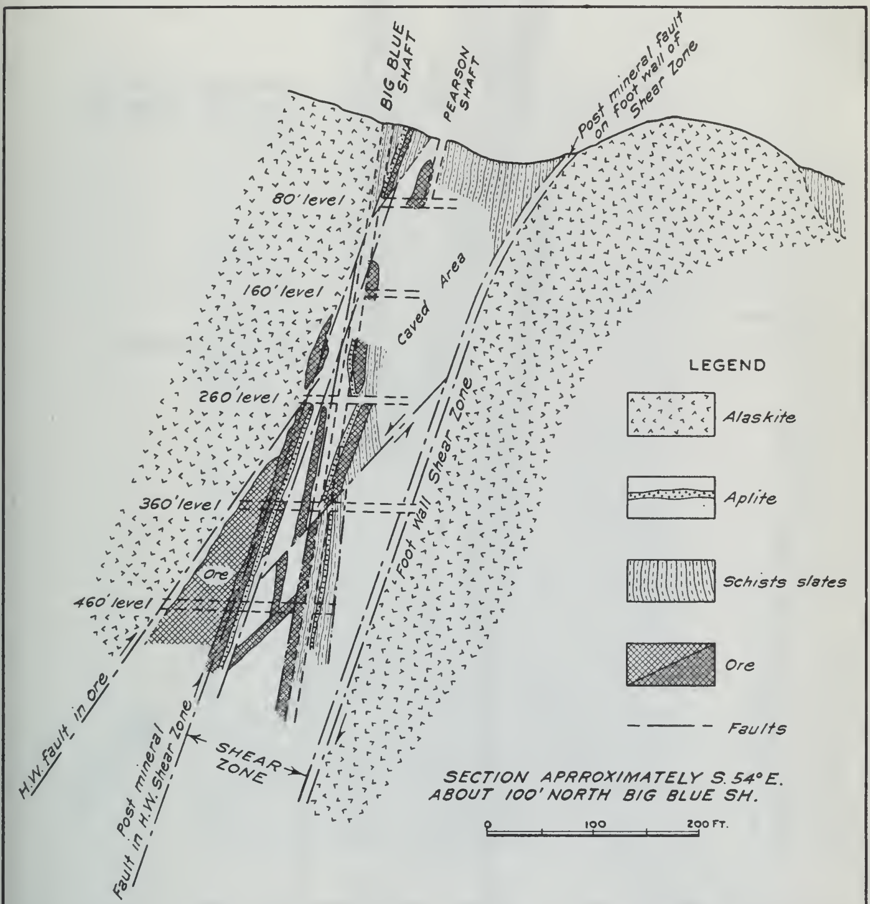


Fig. 8. Cross-section drawn at right angles to shear zone walls, to show approximately the position of pre- and post-mineral faulting in relation to orebodies and shear zone.

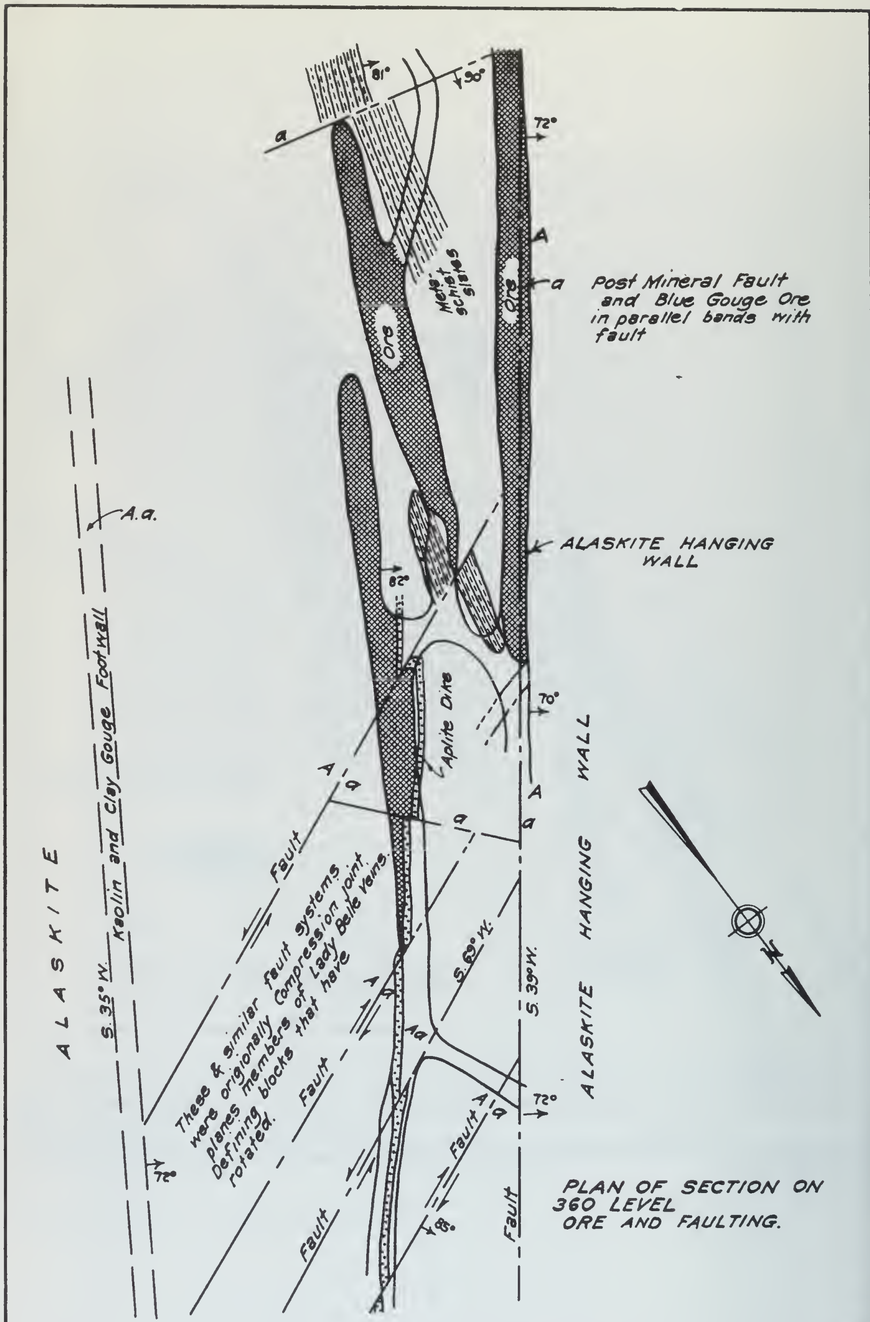

Post Mineral Fault and Blue Gouge Ore in parallel bands with fault
Meta-schists slates
Ore
ALASKITE HANGING WALL
Aplite Dike
ALASKITE
S. 35° W.
Kaolin and Clay Gouge Footwall
These & similar fault systems were origionally compression joint planes members of Lady Belle Veins. Defining blocks that have rotated.
Fault
S. 69° W.
S. 39° W.
ALASKITE HANGING WALL
PLAN OF SECTION ON 360 LEVEL ORE AND FAULTING.
N

FIG. 9.

FIG. 10. Jagged pinnacle outcrops of alaskite east of Cove shaft. Forms the foot-wall of the shear zone.

FIG. 11. Site of the town of Quartzburg, on Cove Flat.

FIG. 12. Outcrop of aplite in hanging wall, Big Blue mine.

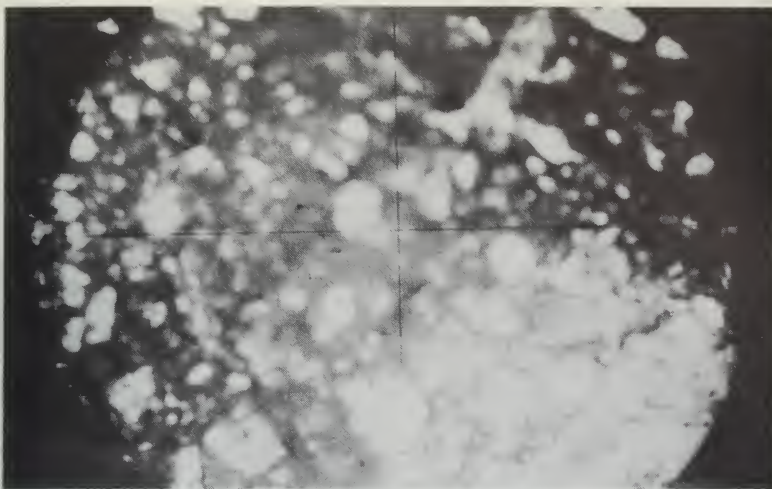


FIG. 13. Photomicrograph of aplite. Light spots quartz, dark spots feldspars and sericite.

FIG. 14. Aplite hanging wall, right, and ore outcrop. Broken fill on left.

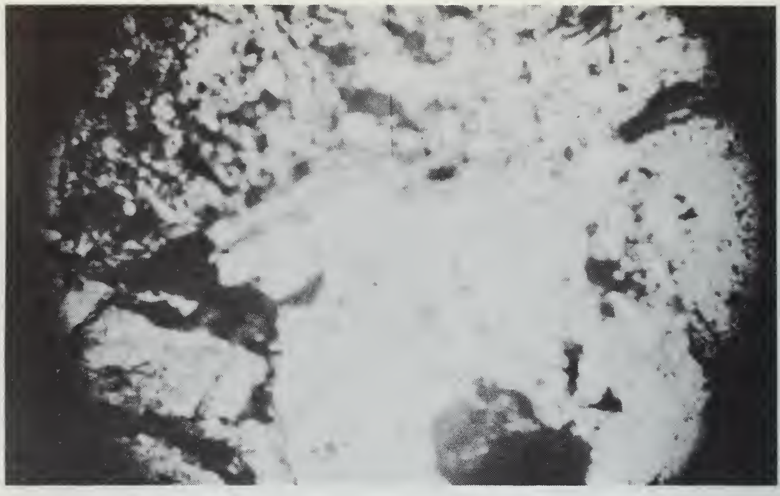


FIG. 15. Photomicrograph of alaskite. Large plagioclase crystal being replaced by sericite (black). The quartz is gray in color, and shows curved surfaces as a result of pressure.

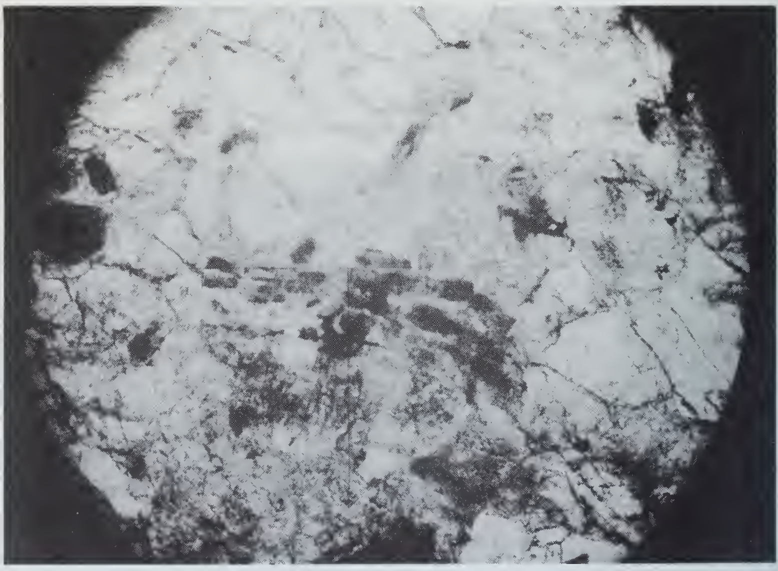


FIG. 16. Photomicrograph of thin section of alaskite under plane polarized light. Light portions shown in outline are original orthoclase; gray portions, albite replacing orthoclase; white portions, quartz. Veinlet contains dark sulphides. Dark spots at the left are sericite replacing feldspars; right center, chlorite. All minerals show strain and pressure cracks that have been filled with later quartz and sericite.

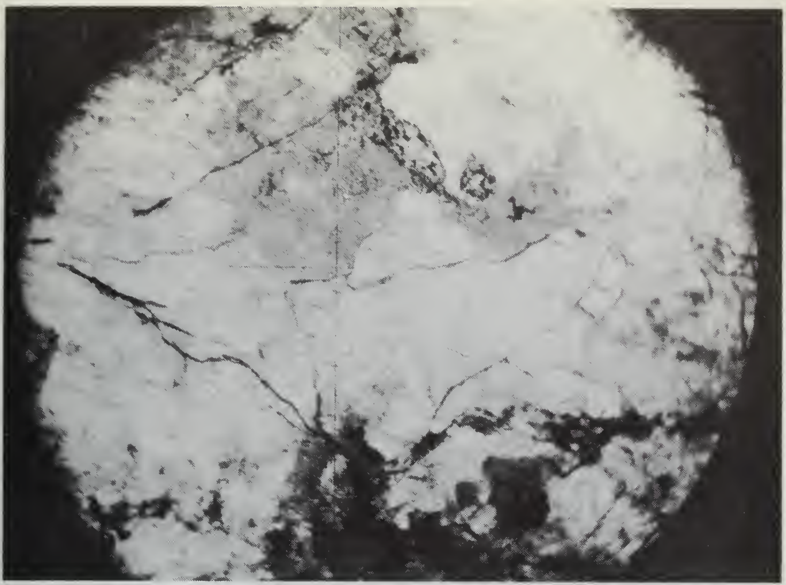


FIG. 17. Photomicrograph of alaskite from the hanging wall of the Big Blue mine, No. 17 west cross-cut 360-foot level. Orthoclase and labradorite are being replaced by albite. Sericite is replacing the feldspars, quartz and chlorite are replacing the ferromagnesia minerals and filling cracks and seams. All crystals are curved, as a result of pressure.

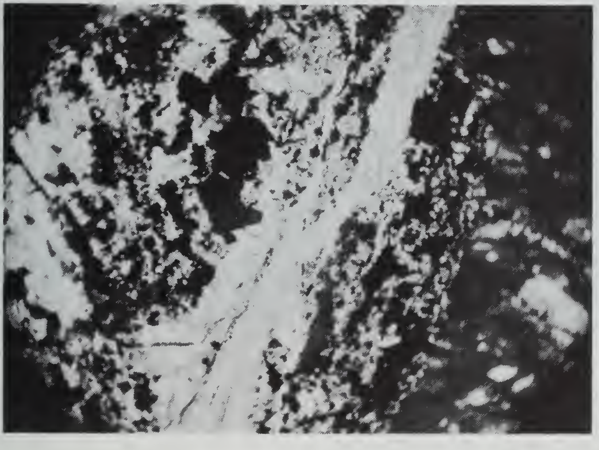


FIG. 18. Photomicrograph of ore from the Big Blue mine. Dark material at the left of the picture is alaskite; light material is veinlet of quartz of the first stage, cut by veinlet of quartz of the second stage; black material, arsenopyrite and sulphides.

FIG. 19. View of the mill of the Big Blue mine.

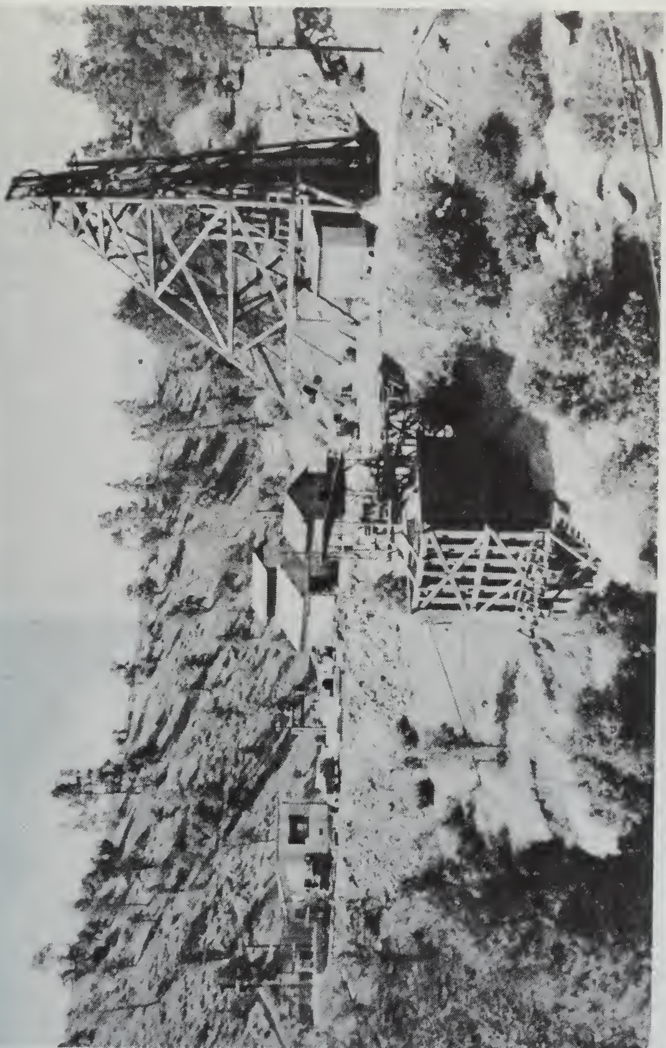


FIG. 20. View of the Big Blue mine shaft headframe and ore loading bin.

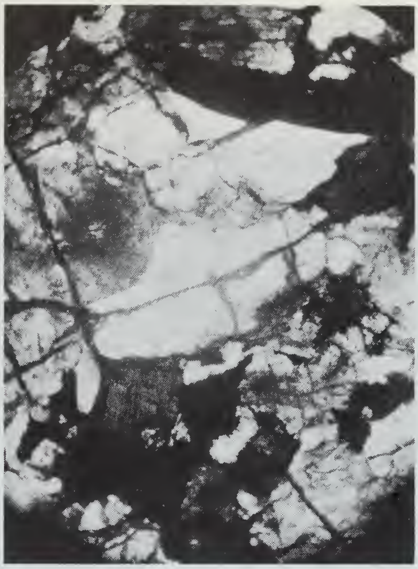


Fig. 21. Photomicrograph of the granodiorite, showing quartz, plagioclase, orthoclase, hornblende and biotite. All crystals are fractured.

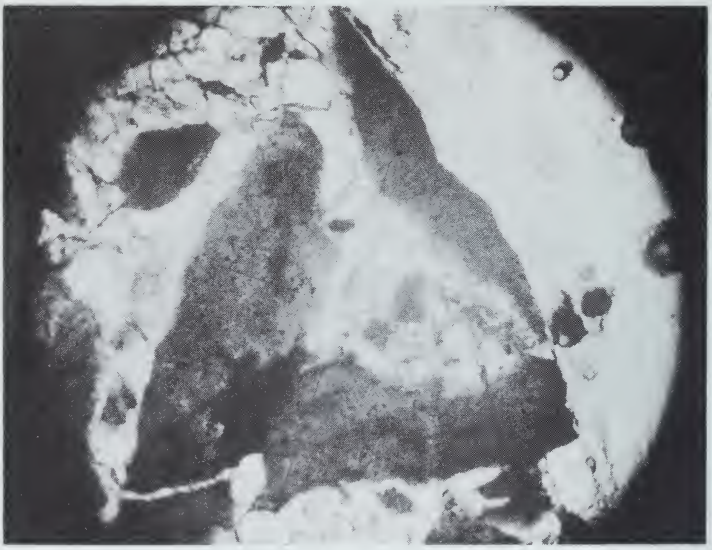


Fig. 22. Photomicrograph of brecciated ore, showing fragments of vein material of the first quartz stage (dark gray) cemented by later quartz (light colored). Sulphides, chiefly arsenopyrite, are black.

MINERALS ASSOCIATED WITH THE ORE

Gold. The gold and silver are mostly found combined. The gold has a fineness of 650 to 700 and the silver 285 to 300.

The gold occurs in all stages of development, mostly in fine particles as small as 17 -microns. Experiments on grinding disclose that 50% or more of the gold is between -150 and -700 mesh and 25% at -1,500 mesh. A petrographic study of thin sections of ore shows that the gold is found in the pure vein quartz and with the sulphides, especially with the arsenopyrite, galena and sphalerite. A photomicrographic drawing shows gold between two crystals of galena, all enclosed in arsenopyrite. Some specimens have the gold in the primary blue vein quartz, while others have it on the boundary planes of the arsenopyrite and quartz. Gold is also in small nuggets and thin plates in quartz with no sulphides adjacent. When found enclosed with the arsenopyrite the order of crystallization and deposition seems to be as follows: arsenopyrite, sphalerite, galena, gold. Gold deposited during the first quartz stage is sometimes found in grooved flakes in quartz, while in other cases it may be possible that the gold was deposited as a colloid.

The small size of the gold may account for the lack of profitable placer mining in the area. The gold as a rule is in such fine particles in the outcrops that its accumulation is made difficult by erosion and the saving of such particles by placer machines is almost impracticable; however, I have found a few small nuggets in the ore visible to the eye.

Calcite. Calcite is one of the latest minerals to deposit and is an alteration product partly produced from the breaking down of soda lime feldspars. Calcite is found replacing plagioclase and plagioclase in turn replaces orthoclase. Calcite crystals are sparingly found in the ore.

Scheelite. Scheelite, the calcium tungstate is in direct association with the aplite and usually occurs in this type of gold-bearing veins. The percentage is small compared to the other metallic minerals. Scheelite is in genetic connection with the intrusive rocks deposited by hydrothermal solutions of intermediate temperatures.

Chlorite. In some instances chlorite of scaly and foliated habit is found in small scattered amounts indicating a basic alkali-free, hydrated origin. It was not formed as a pyrogenic mineral, but by hydrothermal action, probably as a result of the alteration of the aluminous ferromagnesian minerals such as hornblende and biotite. Chlorite is abundant in the hanging wall in small fracture planes and in places along the shear zone where the feldspars are sericitized. The chlorite forms in the strain cracks and as replacements, and is found in ample quantities, sufficient to justify the conclusion that the deposits in part are due to the hydrothermal activity of the solution. Naturally the majority of alterations are found in the shear zone hanging wall. Chlorite is also found in the small stress planes in the ore.

Under plane polarized light the chlorite is green, occupying most all strain cracks. Under crossed nicol light the green color remains

7—93872

prominent. It is a mineral closely related to the micas but more basic and hydrated. The alkali is free and of distinctly basic cleavage.

Quartz. The quartz in the ore has been deposited during two stages of mineralization. The first stage of quartz injection occurred at the time hydrothermal mineralization took place, and the quartz deposited along with such minerals as chlorite, sericite, albite, and the sulphide minerals mentioned below. The hydrothermal mineralization immediately followed the intrusion of the alaskite and aplite. This quartz is bluish in color, usually massive, and indicates formation from a colloidal siliceous melt. Much of the quartz found in the ore contains numerous vacuoles.

The later, or second stage of quartz deposition was injected during the time of faulting. This material is more massive. It is found in abundance as metamorphic contact and replacement deposits. The various processes overlapped one another to the extent that the later stages indicate mesothermal types of ore in the upper zones. The quartz can be used as a gauge to measure the enantiotropic inversion of the alpha trapezohedral tetartohedral quartz to beta trapezohedral-hemihedral quartz, which takes place at about 575° Centrigrade. The vein quartz and the quartz replacing other minerals is alpha low-temperature, and this quartz usually occurred as one of the earliest minerals deposited. The water and mineralizing solutions were differentiation products from the magma. It appears that much of the quartz carried forward by these solutions was in a colloidal condition.

Sericite. Sericite is one of the micas commonly derived from feldspars. Sericite is a hydrothermal mineral which tends to impoverish the original magmatic extract of potash, modified by the presence of heat and vapor. It is found in abundance in the alaskite and aplite, because the altering solutions spread from the main trunk channel through a large area of the adjoining alaskite hanging wall. The process of sericitization is intimately associated with the mineralization and indicates that mineralization commenced at considerable depth.

Barite. Barite is sometimes found in small particles probably derived from the feldspars.

Silver Chlorides. Some chlorides of silver have been found in the upper workings indicating the presence of gases during the process of ore deposition. The mine water shows a slight alkaline reaction on the 360 and 460 levels.

Carbon Dioxide. Carbon dioxide is present in small amounts in the cracks and seams in the wall rocks.

Arsenopyrite. By means of microscopic determinations and chemical analyses made of the ore and concentrates, it is estimated that between 1% and 2% of the ore is made up of metallic sulphides. The important sulphide minerals in the ore are named in their order of abundance as follows, calculated on a basis of 100% metallic sulphides:

Arsenopyrite	85.88
Pyrite and Marcasite	8.81
Galena	3.00
Stibnite	1.30
Sphalerite	0.88
Bismuthinite	0.70
Approximate Total	100.47

The most abundant occurrence of arsenopyrite is with the siliceous parts of the ore; and along with the more massive bluish quartz vein filling it is one of the principal metallic minerals associated with and contained in the ore. It is mostly in crystal form but is also found in the innumerable small veinlets as individual and separate crystals. The veinlets contain angular fragments of quartz and feldspar speckled throughout with arsenopyrite. In addition to the arsenopyrite the following hydrothermal metallic minerals have been found: magnetite, pyrite, pyrrhotite, scheelite, molybdenite, bismuthinite, sphalerite, and sulphantimonides. The mineralization of the vein material was accompanied by processes of pyritization, sericitization, and silicification. The above paragenesis is more indicative of the first quartz stage.

MAGMATIC EXTRACT AND ORE

The magmatic extract was definitely in a state of aqueo-igneous fusion producing alaskite-aplite.

The early stage of quartz deposition occurred along lines of faulting, and the quartz was deposited as a precipitant; but in most cases the filling was crushed and broken. The presence of arsenopyrite far removed from the veins in small fracture planes extending outward into the walls from the ore suggests formation under conditions of pressure and temperature.

The alaskite congealed from the magma. With the pressure diminishing during the ascent of the magma to higher levels the water and other mineralizers separated from the magmatic solutions and carried with them constituents of the vein. Mineralization commenced at a higher level than the "roots" of the magma. The veins commenced to be formed soon after this activity, perhaps by a sharply defined epoch of mineralization with the temperatures gradually declining during the first stage of quartz injection. It is my opinion that the magmatic and pyro-metasomatic deposition occurred in the following sequence. The gangue minerals were early and the ore minerals followed later. The various stages of quartz injection into the veins overlapped and continued for a rather long period of time. Theoretically the tungstic acid which formed scheelite had a tendency in the early stages of deposition to liberate silica at the lower range. At the higher range of temperature the reverse of this may be true, with the re-absorption of the silica to form scheelite. The quartz in the plutonic rocks is undoubtedly conditioned by pressure. In the earlier stages the order of deposition was about as follows: silicates, oxides, pyrite, pyrrhotite, arsenopyrite, sphalerite, galena, sulphantimonides. The gold and silver were deposited beginning with the first quartz stage and continuing throughout the second period.

The principal mineralization occurred in the shear zone and extended into the alaskite hanging wall. The ground waters have been circulated throughout the surface outcrops and have oxidized the sulphides.

A few additional observations and deductions are presented which are of further diagnostic value in substantially corroborating the view held that the orebodies were formed by hydrothermal activity representing the first stages of mineralization, while replacement and metamorphism represent the second stage. It is to be distinctly understood, however, that these stages of mineralization were continuous, with one period overlapping the other and with no exact defining line between the two.

The number 503 orebody located approximately midway between the hanging and foot walls of the shear zone, is a displaced, faulted section of ore, originally a part of what is known as the Dunston orebody, which was mined on the 260 level. This orebody dips about 38° westerly, and is delimited by two 72°-dipping fault planes. The original quartz matrix of this ore is rather coarse grained. It has been recemented by later quartz and the original feldspars of the alaskite have been completely replaced by albite, and the albite partly replaced by sericite and chlorite.

The later stage of mineralization has somewhat increased the sulphide content along fault planes, particularly the arsenopyrite. Such conditions produce ore of better grade.

Metasomatic replacements occur in the later stages of quartz development. All of the minerals show abundant strain and pressure cracks filled with later quartz, sericite, chlorite, and sulphides. There seems to be no question but that the second stage of mineralization enhanced the value of most of the ore found in the Big Blue and permitted conditions wherein the volume of the ore was increased and local planes enriched. Overthrusting is evidenced by a system of faulting on a minor scale which formed a series of step faults whereby one block above another has been pushed east towards the foot wall. East of this orebody and nearer the shaft is a small aplite dike accompanied by some mineralization. This dike is inclosed by a sheet of schistose rock and slaty material and has no ore of value. In many similar conditions the ore may assay about $1.00 per ton.

Within a few feet of the foot wall of the fault which delimits 503 orebody on the west, the main 501 orebody commences and extends to the major post-mineral fault in the shear zone, then continues westerly from 20 to 40 feet into the alaskite which forms the hanging wall. Along the major post-mineral fault the main orebody has had the vein material rearranged and brecciated giving the ore adjacent to the fault an appearance of a banded structure; this appearance, however, is due entirely to the faulting and is a secondary result.

Usually, when a block of the sediments is encountered, the mineralizing solutions migrate around it. Now and then one of these blocks has been shattered, permitting solutions to migrate into it and form lower-grade ore.

Alaskite forms the hanging wall of the 501 orebody and as elsewhere on the property, it has been completely shattered and fractured, developing tension and stress planes which permitted mineralizing solutions to migrate. Precipitation of the ore minerals induced by a lessening of pressure and temperature in the solutions was sufficient to produce ore of commercial grade.

In the faulted section of the veins and ore shoots intense dynamic metamorphic action has taken place. As a result of this the original ore was brecciated and all the pieces rearranged and recemented by later quartz. Most of these fragments are angular, but in some cases the edges are rounded. There is a regular zonal arrangement of the small sulphide minerals in some of these brecciated fragments. Now and then a crystal of secondary arsenopyrite appears along with a few small crystals of plagioclase and albite with a minor amount of green chlorite in the brecciated ore, especially where it is adjacent to later post-mineral faulting.

GENERAL RELATIONSHIP OF DIKES AND ORES

It is well to mention again that the aplite dikes are found in direct association with the orebodies and at the time of their intrusion the mineralizing solutions followed the same line of weakness and deposited their mineral and silica burdens to form the mineral deposits.

The orebodies within the shear zone exist as definite ore shoots distributed irregularly between the hanging wall and the foot wall, but the siliceous extract was deposited in quantity for long distances adjacent to the hanging wall. The orebodies have a pitch across the dip, and in some cases, as in 501 orebody, the pitch is southerly; however, on the 260 and 360 levels No. 1 and No. 2 orebodies are nearly vertical and so is the Pinery, north of the Cove shaft.

Aplite grades to an almost pure quartz or silexite where the quartz is glassy with a pale blue color and the original feldspars, replaced by silica, leave only the skeleton form of the feldspars. It is quite evident that much of the original quartz in the vein was produced from the parent magma responsible for the alaskite, aplite and silexite because of the graduations in amount of quartz contained in alaskite to that in silexite. Hydrothermal activity combined with certain extracts from the intrusives were undoubtedly the responsible agencies for the deposition of the metallic minerals. Reactions due to hydrothermal replacements are essential to the development of the albite. The quartz of the alaskite has its position defined by the potassium feldspar and is later than the feldspar.

The sulphide minerals replace abundantly the feldspars of the alaskite. The feldspars are at times greatly altered not only by hydrothermal activity forming sericite which in turn replaces the albite and other feldspars, but by a later or a second-stage process of mineralizing activity. Much evidence shows that the feldspars are saussuritized especially between the quartz and feldspars. The alaskite is completely shattered and many veinlets composed of ore minerals are formed in it. These veinlets are branches from a common channel and vary from microscopic structures to orebodies several feet in width. Sometimes the ore is spotted, having a headcheese appearance.

The mineral-bearing solutions in their ascent followed channels of least resistance. Mineral deposition commenced and not only filled the open spaces in the Big Blue shear zone, but invaded fractures formed in the granodiorite and reached far into the alaskite wherever the hanging wall was shattered. Under such conditions the most productive orebodies occur.

The ore was deposited in shoots having a dip with the hanging wall about 72° and a pitch to the south. The main orebody on the 360 and 460 levels averages 500 feet long elliptical in horizontal section with a maximum width of 60 feet near the center. During the first stage of deposition the gold was deposited in a coarse grain quartz. The post-mineral faulting has created a typical banded structure in the ore. A high degree of metamorphic action occurred on each side of the fault, and extended into the walls several feet from the fault plane.

The commercial ore in the alaskite is determined in two ways, first by the assay values and second by a well-defined compression joint plane in the alaskite along which a fault developed, limiting the area of mineralization. This fault plane has a strike of N. 10° to 15° E. making an acute angle of about 45° to the Lady Belle system, which strikes N. 60° E.

LADY BELLE VEIN SYSTEM

This system includes those veins which have a general course N. 60° E. and are formed in one set of the compressional joints.

The Jeff Davis, Bull Run, Lady Belle, Frank, Urbana, and Beauregard veins represent a parallel vein system with the exception of the Frank and Urbana. These two latter veins strike N. 45° E.; the others strike N. 69° E. They were all formed by the same forces which produced the Big Blue fracture, resulting in a system of compressional joints with their orientation governed by the direction and application of the pressure. These are a part of the same flexed system of movement. The Lady Belle and Bull Run veins appear to have the greatest length and best ore. They are mineralized at intervals for a distance of approximately 1400 feet extending from the shear zone to the west.

The veins are mineralized by the same character of solutions but are of less volume and magnitude than those which formed the orebodies in the Big Blue; however, these fractures, or joint planes, being farther removed from the source, do not contain aplite dikes, so consequently the mineralization was limited to the amount of excess or overflow of the solutions required for the Big Blue zone. These veins were mineralized by overflow solutions from the main trunk channel. Erosion has planed down the veins to their present outcrops and I am confident these ores never reached the original surface but were exposed by erosion. Underground we find orebodies which do not outcrop on the present surface.

The mineral-bearing solutions migrated through cross courses or intersecting members and by making connections with the main channel they permitted the solutions to be forced laterally into those planes, forming ore. The width of these veins depended entirely on the delimiting walls. These solutions became cooler and less active by their long migration and therefore those orebodies are of much smaller dimensions, usually 2 feet to 4 feet wide. With less sulphides deposited the same relative proportionate amount of gold in the quartz tends to increase the value per ton of ore. It is reported much of this ore averages $12.00 to $20.00 per ton.

Cross sections through the Big Blue zone show that on the same mine level there may be two or more faulted portions of orebodies between the walls. In previous years these planes were called the east vein, middle vein and west vein. The mineral-bearing solutions migrated continuously throughout the shear zone, extending from the foot to the hanging wall. Whenever these solutions came in contact with impervious formations they migrated around them, forming ore. At some places above these impervious blocks the solutions joined and continued on the lateral and upward movement producing pulsating currents. After deposition subsided there was a renewal of the faulting and the ore was displaced in many cases 100 or more feet laterally and vertically. There are many cases where a system of faults make an acute angle with the walls of the shear zone. In these instances an orebody near the hanging wall may be faulted and displaced on one of these planes, while at the same time another orebody which might be midway between the walls would not be affected where it occurs between the walls in the same vertical section. At other times a fault may pass between two or more orebodies affecting one or the other or both. It has been found that displaced sections of different orebodies, if projected on a plane parallel to the vein, would overlap.

MINE WORKINGS AND DEVELOPMENTS

The Lady Belle vein system, including the Jeff Davis, Bull Run, Frank, Urbana, and Beauregard, has produced a considerable quantity of ore through several thousand feet of development work. The deepest part of these workings is the Lady Belle shaft, 438 feet. At least a dozen shafts have been sunk at different periods of time to various depths, but probably the largest production came from the Lady Belle, Jeff Davis, and Bull Run claims. All of the old stopes are caved and inaccessible and no reliable estimate can therefore be made as to the quantity and value of the ore extracted.

The mines have been opened by shafts and tunnels. The early workings consisted of shallow shafts and tunnels which produced a considerable amount of oxidized surface ore, mostly on the Sumner and adjacent claims through which the Sumner gulch traverses. The north tunnel was one of the earlier workings from which ore was extracted from the Pinery and Jeff Davis. The Big Blue was not found until the late sixties or early seventies, when by chance some work was done from the North tunnel, which found ore in the mine somewhere near the Cove shaft.

TUNNELS

Four tunnels enter the veins, driven west from the hillside. The North tunnel in the Sumner gulch attained a depth of about 160 feet below the surface on the Jeff Davis claim.

In the early seventies the Pioneer tunnel was driven from the Big Blue gulch to intersect the Big Blue vein near the Sumner shaft at about 80 feet below the surface. Production was made through this tunnel to a surface bin from where the ore was trammed on a surface track to the mill.

The Big Blue drain tunnel was driven from the river over 2,000 feet to connect with the Sumner shaft. This level underground is known as the 260 level, and was completed in 1883.

The Grave Yard or South tunnel is 500 feet long and intersects the Big Blue zone about 150 feet below the surface and 650 feet south of the Big Blue shaft.

SHAFTS

The Sumner or Engine shaft was sunk on the Big Blue vein near the south end line of the Sumner claim, and it reached a total depth of about 400 feet. The water was a big problem in this shaft, and in the earlier days a steam plant was erected and ''walking beam'' pumps were used; the water was pumped through a 12-inch and 16-inch cast iron column pipe. From this shaft there were driven the 80, 160, 260, and later the 300 levels. The shaft was completely ruined by a fire which swept through the underground workings and surface buildings in November 1883.

The Cove shaft, 350 feet northerly from the Sumner shaft on the strike of the vein, was sunk to a depth of about 240 feet with three levels. The work was done in the Fall of 1908 and Spring of 1909. The 80-foot level connected with the old Pinery orebody north of the shaft and with the North Sumner tunnel. The Pinery orebody was reported as one of the richest on the property and was mined through the North Sumner tunnel.

The Pearson shaft was sunk 80 feet deep in the Big Blue gulch. It was located about 500 feet south of the Sumner shaft and connected with the old workings, but it has been abandoned for many years.

The Big Blue shaft is the main working shaft and is about 510 feet deep. It is inclined to the west at an average angle of 82° and connects with the old workings on the 80, 160 and 260 levels, and also with the new 360 and 460 levels.

The water is pumped from the lower workings and discharged on the 260 level which connects with the River tunnel. This tunnel is now used for both drainage and ventilation and the stopes, raises and Big Blue shaft are all connected to it by drifts and crosscuts. Sometimes, depending upon the season, the Big Blue shaft acts as an upcast and other times as a downcast shaft, affording ample opportunity for conditioning the air underground.

The Kern Mines, Inc. commenced their operations on the 360 level, or about 100 feet below the drainage tunnel or 260 level. Since then the workings on the 360 have extended over 1,000 feet northerly, making suitable connections with upper levels for ventilation. On the 360 level there have been opened four separate and distinct ore shoots, varying from 4 feet to 60 feet in width and from 200 to 540 feet in length.

The 460 level is approximately 200 feet below the drainage tunnel. At the time this report is being written the 460 has been partially developed by about 1,000 feet of drifts and crosscuts. One orebody, number 501, has been partially opened for a length of 500 feet and shows a maximum width of 60 feet. This orebody is in the hanging wall section or west side of the ore zone. Number 503 orebody has been developed on this level. It is located between 501 and the shaft and is about 6 feet wide by 200 feet long. All of the orebodies on the 360 and 460 levels have been displaced both horizontally and vertically a considerable distance from their positions on higher levels.

On the surface the Big Blue has been prospected for 8,000 feet along its outcrop by a number of opencuts and shallow shafts which extend along the entire length of the claims through which the shear zone passes. This exploratory work has been carried on for more than 80 years. It is estimated that for 1,200 feet exploration and exploitation of the ore were energetically carried on at intervals during this period of time. This work extended from the Pearson shaft on the south of the main mineralized zone to about 150 feet north of the Cove or Donkey shaft. In places along this zone the ore, which was mined until it was cut off by faulting, reached a depth of 260 to 300 feet below the surface. This work represented several thousand feet of underground drifts, crosscuts, and raises, but since then most all of this area has been caved and made inaccessible. Several years ago it was estimated that about 27,000 feet of underground work had been done above the 260 level. The surface has caved from the Pearson shaft to the North tunnel, a distance of 600 to 700 feet.

MINE EQUIPMENT

The mine is equipped according to good mining practice.

There are three working shafts on the property, the Big Blue, Lady Belle, and Beauregard. The Big Blue is a two-compartment shaft, each compartment 5 feet by 5 feet. It is well equipped to handle ore, materials, supplies, and men. It has a 42 cubic foot self-dumping skip running on guides and wheels with all the safety devices customary in such equipment and is operated by a 48 inch diameter double drum, 150 H. P. electrically driven motor hoist.

The skip is loaded from pockets or cars, and at the surface automatically dumps into a 100 ton capacity receiving bin. The head frame has 9 posts supported on concrete foundations placed so that there is no load on the collar set of timbers of the shaft.

The surface equipment at the Big Blue consists of blacksmith shops with drill sharpener, power saw for sawing mine timbers, change house, ore receiving bin built under the head frame, from which the ore goes to a primary 18 by 20 jaw crusher and is broken down to 3 inch size. The crushed ore is discharged by a belt conveyor to the truck bin, capacity 200 tons, where the trucks load and transfer the ore to the mill's secondary crusher bin.

Power is furnished by the Southern California Edison Company from their transformers at the mill, whence it is carried by the Kern Mine's 2,300 volt, 3 phase power line to a bank of three 75 Kva transformers located at the Big Blue hoist house. From these transformers the power is distributed at 440 volts to the various surface motors. The main 2,300 volt line is carried by an armored waterproof cable down the shaft to three 75 Kva Pyranol transformer stations located on the 260 level. From these the power is distributed to the pump motors on lower levels.

MILLING

The gold, occurring in the ore as free gold and as gold locked up with the sulphides, required a revision of past milling practice in order to place the plant on an efficient economical basis.

Complete chemical analyses and microscopic determinations were made which indicated that the free gold should be extracted by amalgamation, the gold locked up with the sulphides, however, requiring flotation. It was also found advisable to "free" as much of the gold as possible by grinding in so far as was found practicable and economical to do so.

New equipment has been added and numerous changes have been made in the flow sheet. As a result of the combined treatment of the ore by amalgamation and flotation gold bullion is made from the amalgamation unit extracting an average of about 45% of the value, and flotation concentrates extract the remainder or about 55% of the gold. On an average grade of ore the recovery by milling is about 94% to 97%, somewhat depending on the assay of the mill heads, and the average tailings loss is from 17 cents to 25 cents per ton.

The ratio of concentration is from 50 to 1 and 80 to 1, largely depending on the value of the mill heads. The pulp density of the classifier overflow is about 30 and of the tailings about 26.

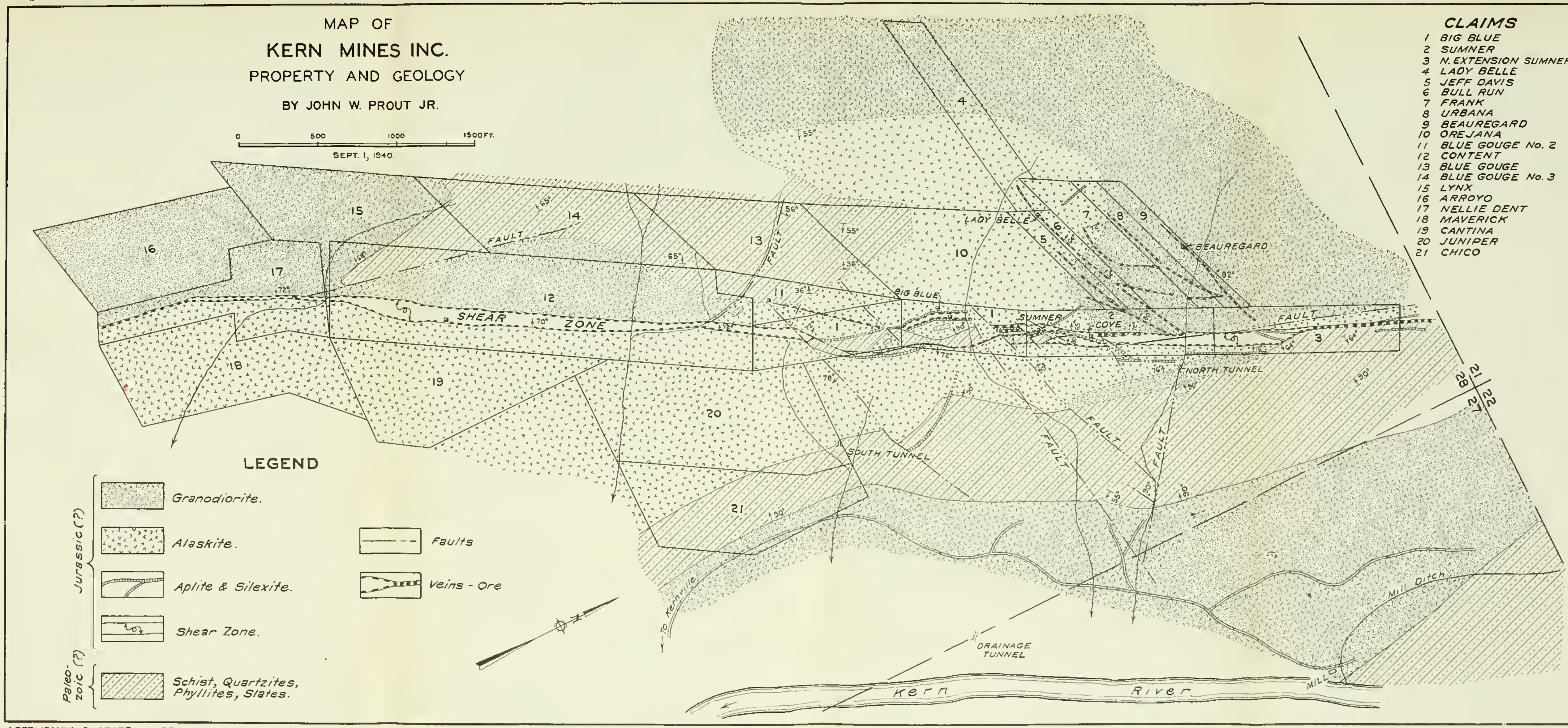
The following flow sheet is used: The ore passes over a $\frac{3}{4}$ inch grizzly from the truck unloading bin, the oversize rock is crushed in a Traylor 8 B.H. Reduction Crusher to $\frac{3}{4}$ inch, and all ore is discharged into a cylindrical storage bin by a bucket elevator. The crushed ore from this bin is automatically fed by a conveyor belt to the 6 by 8 foot Traylor Ball Mill, using 3 inch and 4 inch balls. The mill is in closed circuit with a pulsating jig and classifier. The entire ball mill discharge goes to the pulsator jig which extracts about 45% of the gold and then goes to the classifier. The hutch product from the jig is reground in an amalgamating barrel and the amalgam cleaned in a cleanup unit. The barrel rejects are returned to the classifier. The amalgam is retorted periodically and sent to the United States Mint at San Francisco.

The classifier overflow is pumped to a surge tank and from there it is delivered to 5 rougher flotation cells. The froth from 4 of these goes to a cleaner cell and the froth from the first rougher and the cleaner cell goes to concentrates. The tails from the cleaner cell are returned to the circuit. The tails from the rougher cells discharge to 6 scavenger cells. The froth from the scavenger cells is returned to the circuit and the tailings discharged into the tailings pond.

Screen tests on the tailings give approximately the following sizes: 60% is minus 150 mesh, 40% between 60 and plus 150 mesh. The concentrates show that about 92% of the product is minus 150 mesh and 8% between 60 and plus 150 mesh. The concentrates are pumped to receiving tanks and filtered by an Oliver drum filter and then discharged into a two compartment bin arranged for loading into trucks, which remove it to the American Smelting and Refining plant at Selby. The mill tailings are discharged in a tailings pond across the river.

The water for milling and power for the compressor is taken from the river by a ditch.

The intake of the ditch is about $1\frac{1}{2}$ miles up the river from the mill. It is about 8 feet wide and carries water 4 feet deep. The outlet is at the mill where the water is discharged through a flume to a penstock containing a water turbine, and by pipes to the mill.


MAP OF
KERN MINES INC.
PROPERTY AND GEOLOGY
BY JOHN W. PROUT JR.
0 500 1000 1500 FT.
SEPT. 1, 1940.
CLAIMS
1 BIG BLUE
2 SUMNER
3 N. EXTENSION SUMNER
4 LADY BELLE
5 JEFF DAVIS
6 BULL RUN
7 FRANK
8 URBANA
9 BEAUREGARD
10 OREJANA
11 BLUE GOUGE No. 2
12 CONTENT
13 BLUE GOUGE
14 BLUE GOUGE No. 3
15 LYNX
16 ARROYO
17 NELLIE DENT
18 MAVERICK
19 CANTINA
20 JUNIPER
21 CHICO
LEGEND
Jurassic (?)
Granodiorite.
Alaskite.
Aplite & Silexite.
Shear Zone.
Paleozoic (?)
Schist, Quartzites, Phyllites, Slates.
Faults
Veins - Ore
SHEAR ZONE
FAULT
LADY BELLE
BEAUREGARD
BIG BLUE
SUMNER
COVE
NORTH TUNNEL
SOUTH TUNNEL
DRAINAGE TUNNEL
Kern River
Mill Ditch
MILL
To Kernville
21 22
28 27

The water turbine is belt-connected to an I. R. Imperial type 10 air compressor which in turn furnishes air to the mine and mill.

SUMMARY AND CONCLUSIONS

It is quite evident from a study of photomicrographs that no single period of mineralization nor any one type of ore can be assigned to these deposits.

The deposition of the gold and silver commenced with the expulsion of the magmatic extract, and there were features of alteration and redeposition that were in common with different processes. It appears that there was a sort of pyrometasomatic succession combined and connected with the hydrothermal development in the siliceous rocks. The various processes overlapped one another. The metallic minerals are small in volume compared to the gangue volume, and consist of the simple sulphides and arsenides with some magnetite and pyrrhotite. The quartz and silicates are the predominating and persistent minerals in the gangue.

Banding and crustification are lacking except in so far as subsequent movements along the fault planes have rearranged the vein filling, in such cases they have the appearance of a banded structure. In these later stages of quartz development and rearrangement a moderate amount of metasomatic replacement occurred. Replacement phenomena include the reaction of the hydrothermal solutions on the original magma to form albite.

The joint reactions produced by heat and water are referred to as aqueo-igneous.

Alaskite, aplite, silexite and quartz of the first stage are end products formed as a result of the differentiation of the granitic intrusive rocks. The metamorphic products are the result of processes accompanying faulting.

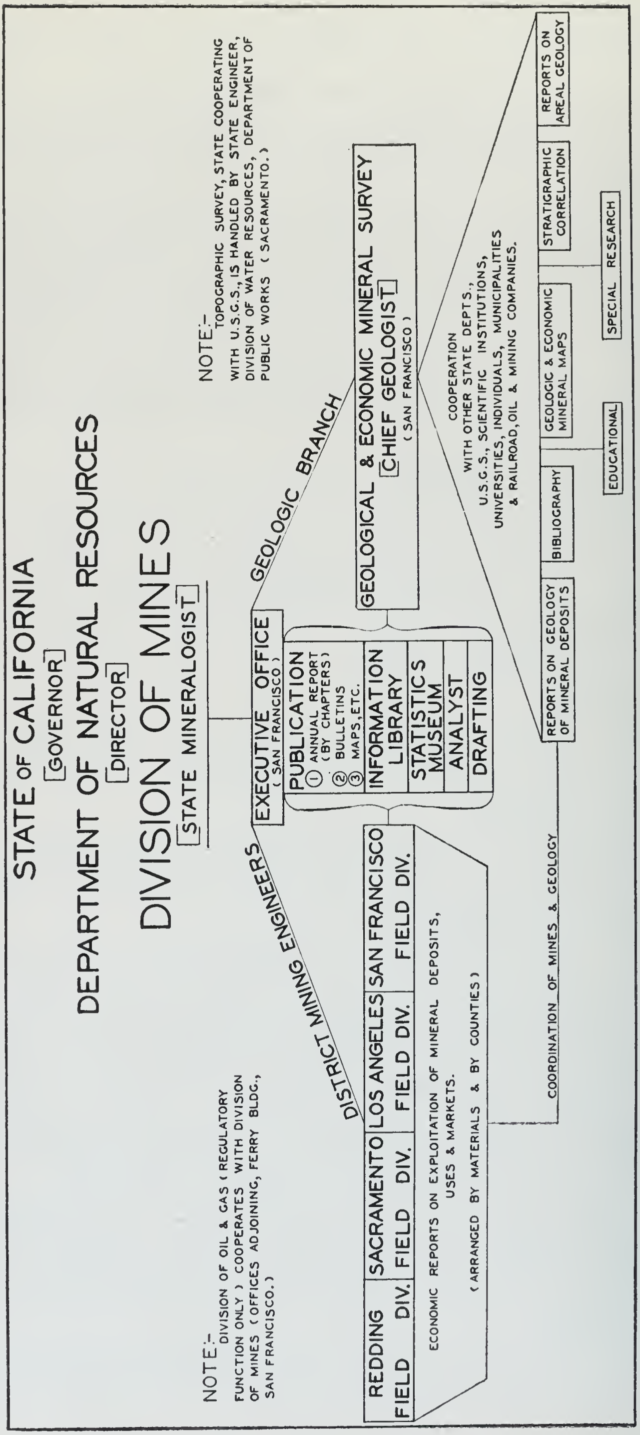
Naturally the hot ascending emanations would change to intermediate temperatures in higher zones, as is typical of the mesothermal type of deposit. The range in temperature could have been from hypothermal to epithermal.

From a broad viewpoint it is believed the ore was formed as a result of the combined processes accompanying hydrothermal activity.

The writer has endeavored to present the geological evidence upon which his deductions and conclusions regarding the gold veins of the Kern Mines have been made. The major features have been discussed at some length and sometimes reviewed with the hope that the many complex problems will be better understood. The type, classification and association of these commercial ore deposits are considered to be an exception rather than the rule as found in California.

There were many overlapping processes of mineralization which produced the ore and these, in connection with the pre-mineral and post-mineral faulting, have caused many complex geological problems. The mechanics of the vein formation and faulting, along with the chemical alterations of the rocks and minerals, has had to be kept in mind at all times.

The deposition of the primary ore followed the granodiorite intrusion. The veins were exposed by erosion and the present surface by no means represents the original one.


STATE OF CALIFORNIA
[GOVERNOR]
DEPARTMENT OF NATURAL RESOURCES
[DIRECTOR]
DIVISION OF MINES
[STATE MINERALOGIST]
NOTE:- DIVISION OF OIL & GAS (REGULATORY FUNCTION ONLY) COOPERATES WITH DIVISION OF MINES (OFFICES ADJOINING, FERRY BLDG., SAN FRANCISCO.)
NOTE:- TOPOGRAPHIC SURVEY, STATE COOPERATING WITH U.S.G.S., IS HANDLED BY STATE ENGINEER, DIVISION OF WATER RESOURCES, DEPARTMENT OF PUBLIC WORKS (SACRAMENTO.)
DISTRICT MINING ENGINEERS
EXECUTIVE OFFICE (SAN FRANCISCO)
GEOLOGIC BRANCH
PUBLICATION
1 ANNUAL REPORT (BY CHAPTERS)
2 BULLETINS
3 MAPS, ETC.
INFORMATION LIBRARY
STATISTICS MUSEUM
ANALYST
DRAFTING
REDDING FIELD DIV.
SACRAMENTO FIELD DIV.
LOS ANGELES FIELD DIV.
SAN FRANCISCO FIELD DIV.
ECONOMIC REPORTS ON EXPLOITATION OF MINERAL DEPOSITS, USES & MARKETS.
(ARRANGED BY MATERIALS & BY COUNTIES)
GEOLOGICAL & ECONOMIC MINERAL SURVEY
[CHIEF GEOLOGIST]
(SAN FRANCISCO)
COOPERATION WITH OTHER STATE DEPTS., U.S.G.S., SCIENTIFIC INSTITUTIONS, UNIVERSITIES, INDIVIDUALS, MUNICIPALITIES & RAILROAD, OIL & MINING COMPANIES.
COORDINATION OF MINES & GEOLOGY
REPORTS ON GEOLOGY OF MINERAL DEPOSITS
BIBLIOGRAPHY
GEOLOGIC & ECONOMIC MINERAL MAPS
STRATIGRAPHIC CORRELATION
REPORTS ON AREAL GEOLOGY
EDUCATIONAL
SPECIAL RESEARCH

SPECIAL ARTICLES

BIENNIAL REPORT OF THE STATE MINERALOGIST

HON. RICHARD SACHSE, Director,
Department of Natural Resources,
Sacramento, Calif.

Sir: Herein I have the honor to present the biennial report of the State Mineralogist as required by law (Stats. 1913, Chap. 679; and Stats. 1939, Chap. 93) for transmittal to His Excellency, Governor Culbert L. Olson, covering the work and activity of the Division of Mines of the Department of Natural Resources, for the period July 1, 1938, to June 30, 1940.

General Summary

April 16, 1940 marked the 60th anniversary of the signing by Governor George C. Perkins (later United States Senator for California) of the bill introducted in the legislature by Assemblyman Joseph Wasson of Mono and Inyo counties, by which the State Mining Bureau was created, with headquarters in San Francisco. Under the authority of that act, Mr. Henry G. Hanks was shortly thereafter commissioned the first "State Mineralogist" of California.

Previously there had been two short-lived "geological surveys" in this state: the first under John B. Trask as State Geologist, 1853-1856; the second under James D. Whitney, 1860-1873. The fundamental idea underlying the creation of the State "Mining Bureau" was that it should be concerned primarily with an economic developmental survey of California's mineral resources and their utilization rather than solely as a "geological" survey. Provision was also made, however, in the organic act that geology should be included in the work of the bureau.

By enactment at the 1927 legislative session, Article IIj was added to the Political Code creating the Department of Natural Resources, and provided for the transfer of the State Mining Bureau to the new department as the "Division of Mines and Mining." This was amended in 1929, changing the name to "Division of Mines" and creating a "State Mining Board" to consist of five members whose duty is to determine "general policies for the guidance of the Division of Mines."

The following have served as State Mineralogist: Henry G. Hanks, 1880-1886; Wm. Irelan, 1886-1893; J. J. Crawford, 1893-1897; A. S. Cooper, 1897-1901; Lewis E. Aubury, 1901-1911; Wm. H. Storms, December, 1911-February, 1913; Fletcher Hamilton, 1913-1923; Lloyd L. Root, February, 1923-July, 1928; the incumbent, since August 1, 1928.

Besides the main headquarters with offices in the Ferry Building, San Francisco, including the library, laboratory, and mineral exhibits, district mining engineers are stationed with offices at Sacramento, Los

Angeles, and Redding. Reports and bulletins to a total number of over 150 have been published from time to time describing in detail (with maps, charts, and photographs) the varied mineral substances available in this great commonwealth of California—their location, character, transportation facilities, state of development, utilization, and other pertinent data.

Looking back over the past two years, the staff of the Division of Mines can view with genuine satisfaction the amount and quality of the work accomplished in behalf of the mineral industries of California. This state is an extensive empire and has widespread and diversified resources of minerals not excelled by any other equal area on the face of the planet. It is a big task for the small staff of the division to adequately cover this large assignment and keep up-to-date on the economic developments in all of the varied mineral industries and areas within our borders. That we have accomplished much, commensurate with the means available, is testified to in letters and oral commendations from many identified with our mineral industries, and is evidence of the loyalty and sincere interest of the staff in their field of endeavor.

Activity has continued unabated in gold mining in California, the yield for the calendar year, 1939, having been 1,435,264 fine ounces and $50,234,240, being the highest value since 1856 and the largest number of ounces since 1862. The oil fields have likewise continued active, where geophysical prospecting followed by drilling has resulted in the discovery of several new pools, particularly in the southern end of the San Joaquin Valley area. Building and structural materials as well as nonmetallic industrial minerals and salines have varied, some being active while others have fluctuated considerably. Since the beginning of war operations in Europe, much attention is being given to inventorying and developing our domestic resources of certain "strategic" minerals important to the United States in our national defense program. These include quicksilver, manganese, tungsten, antimony, chromite, of which Califorina has both currently active and potential resources.

Laboratory

The mineral technologist in the laboratory of the division headquarters office has been kept particularly busy, with his assistant (part time) in identifying and classifying samples sent in from every section of the state. Our files show 17,790 determinations made of which 15,390 were samples mailed or brought in to the division to ascertain their commercial possibilities, if any, and in all of which cases a written laboratory report was given. These samples were mainly from the southern part of the state. San Bernardino, Kern, Inyo, Los Angeles, and Riverside counties sent in the most samples, in the order named. The balance of the determinations were made and oral reports given on materials submitted with the request that immediate information was necessary. This is an increase of about 35 per cent over the 13,190 samples determined during the preceding biennium. As a result of these determinations it was found that many samples had commercial possibilities. This information was made available to the public through our own Commercial Mineral Notes and the Department of

Natural Resources publication, "The California Conservationist." The increase in the number of samples is due primarily to two things: first, the natural growth of the department; and second, to the European War which has brought again to the public the need for strategic minerals such as chromite, manganese, tungsten, quicksilver, quartz crystals, mica, and antimony, all of which may be found in California, as already noted.

The laboratory has aided many mineral collectors in identifying their specimens; has represented the division at California county fairs to judge mineral exhibits; and whenever called upon, has furnished a speaker to address the numerous mineral societies in California, which have had a tremendous growth in the last few years.

The State Mineralogist and other members of the staff also frequently appear before luncheon clubs, lodges, Chambers of Commerce, schools, and other groups, speaking on the mineral industries and resources of this state. These talks are usually illustrated by lantern slides.

A close contact has been maintained at all times with the Department of Geological Sciences at the University of California which has resulted in the determination of many unusual rocks and minerals; also new or more efficient methods of making determinations have been developed.

Additional work by the laboratory is instruction in mineralogy and prospecting given to the veterans of the Mt. Diablo and San Ramon C.C.C. Camps in Contra Costa County. The educational program there is briefly outlined by Mr. George L. Gary, our Mineral Technologist, as follows:

> "The Mt. Diablo and San Ramon C.C.C. Camps near Danville in Contra Costa County are established for war veterans only. At these camps a considerable number of veterans are being trained as a part of the educational program to work in the mines and to prospect for commercial minerals. There are three agencies sponsoring this work: first, the Federal Government which supplies some of the quarters and some of the money; second, the School District of Contra Costa County which supplies some of the quarters and most of the money; and third, the Division of Mines which directs the work and provides evening instruction by members of its staff."
>
> "The instruction in mineralogy is divided into four parts. The first part consists of blackboard lectures on the identification of rocks, and the origin, occurrence, and association of minerals. The second part consists of the identification of all strategic and commercial minerals. The third part consists of the chemical examination of minerals and the general principles of chemistry as applied to minerals. The fourth part of the work consists of field trips to certain of the geological provinces of the State where commercial minerals are found and brings the men in contact with mine managers and superintendents."
>
> "It is indicated that this work, which was started in the fall of 1939, is practical and successful for the following

reasons: first, the commanding officers and educational advisors of the camps report that it is the best program that has ever been offered to the men; second, the Board of Trustees of the School District in which the camps are located report that it is the most practical course given in the camps and the only course offered to the men which they are willing to support; third, inspectors from the Educational Advisory Service, Washington, D. C. report that they will advise their superior officers in Washington to put a similar course into other veteran C.C.C. Camps; fourth, some of the veterans have obtained employment in the mines and others have taken up mining claims as a result of this training."

Two articles have been written by the Mineral Technologist for the California Journal of Mines and Geology—"Sulphate Minerals of the Leviathan Mine, Alpine County," and "Beryl, with a Qualitative Analysis for Beryllium," the latter because of the public interest in the wider use of beryllium in munitions, more specifically in vital parts of airplane engines.

On account of the growth of the laboratory and due to public demand, it is requested that this department be given a full-time laboratory helper and a full-time stenographer. This additional help is needed to maintain the efficiency of the department and to render a more complete service to the public than it is able to do now.

W.P.A. Projects

Successive renewals have been obtained of the Federal Works Progress Administration projects in the San Francisco headquarters office of this division, also for the mining-claim mapping and records projects in the Sacramento and Los Angeles offices. The clerical, cataloguing, indexing, and map-making project in the San Francisco office was renewed each year, though the personnel so employed was reduced in July 1939 to 30 from the previous total of 60 on account of the completion of parts of the program. One of the important items on this program has been the binding of a large number of pamphlets, paper-covered books, and magazine files which will be a permanent asset in the library of the division.

Geologic Branch

A definite and practical plan of work has been consistently followed by the Geologic Branch, and, as a result, much progress has been made in the past two years.

The plan:

(a) To continue geologic mapping of areas not hitherto adequately covered.

(b) To encourage geologic research workers (especially those associated with our universities) to make systematic investigations of worth-while problems regarding the geology and mineral resources of the State.

(c) To act as a clearing-house for geologic information concerning California.

(d) To release valuable reports which have been carefully prepared but never published: example, the forthcoming reports on chromite and manganese (important strategic minerals).

(e) To carry on state-wide investigations, especially those of importance as an aid to the progress of national defense.

(f) To prepare a series of State maps (using the same base as that of the Geologic Map of California) to show the distribution and evaluation of economic minerals—especially those of importance in the program of national defense.

(g) To submit for publication the results of work as soon as they can be put in proper shape for publication.

The high quality of the work which the Geologic Branch has already done is reflected in the whole-hearted support it receives from geological departments in scientific and commercial organizations throughout the State and elsewhere, and from individuals whose professional standing is unquestioned.

The staff of the Geologic Branch now consists of three persons: (1) Chief Geologist, (2) Geological Clerk, and (3) Geological Draftsman. There is now much need of a stenographer to assist in the office, and of an assistant geologist to carry out certain assignments in the field, especially in the coordination of economic applications to the results of scientific investigations.

More funds are needed for publication to release valuable information to the public. The Geologic Branch now has on hand many reports —both completed and in preparation—for which there are at present insufficient funds to make them available to the public.

Dr. Olaf P. Jenkins, Chief Geologist, lists the following:

"REPORTS PREPARED UNDER THE DIRECTION OF THE GEOLOGIC BRANCH

"PUBLISHED

"Sulphur Deposits of Inyo County, California, by Edward D. Lynton (October 1938).

Geology and oil possibilities of southwestern San Diego County, by Leo George Hertlein and U. S. Grant IV (January 1939).

Tertiary formations of northern Sacramento Valley, California, by Charles A. Anderson and R. Dana Russell (July 1939).

Geology and oil possibilities of Caliente Range, Cuyama Valley, and Carrizo Plain, California, by J. E. Eaton (July 1939).

Bibliography of the geology and mineral resources of California, for the year 1937, by Solon Shedd (July, 1939).

The giant Goose Lake meteorite from Modoc County, California, by Earle G. Linsley (July, 1939).

Quicksilver resources of California, by Alfred L. Ransome, and John L. Kellogg (October, 1939).

Economic mineral map of California No. 1, Quicksilver, prepared under the direction of Olaf P. Jenkins (1939).

"IN PRESS

Geologic formations and economic development of the oil and gas fields of California, Bulletin 118, to appear in four parts, prepared under the direction of Olaf P. Jenkins (1940). Part One has been released; Part Two is in press; Parts Three and Four are in preparation.

General geology and ores of the Blind Spring Hill mining district, Mono County, California, by Alfred L. Ransome (April 1940).

Geology of the Newberry and Ord Mountains, San Bernardino County, California, by Dion L. Gardner (July, 1940).

Geology of a portion of the Calico Mountains, San Bernardino County, California, by Homer D. Erwin and Dion L. Gardner (July, 1940).

"IN PREPARATION

The tungsten resources of California, by John F. Partridge, Jr.

Investigation of the economics, resources, and mining of chromite in California, by Leonid Bryner.

Geologic investigation of the chromite deposits of California, by John Eliot Allen.

Descriptive geology of the Kernville quadrangle, California, by William J. Miller and Robert W. Webb.

Geology of the Big Blue mine, Kernville, California, by John W. Prout, Jr.

Economic mineral map to show strategic minerals other than quicksilver, i.e., tungsten, chromite, manganese, antimony, tin, and nickel.

Manganese deposits of California, by N. L. Taliaferro.

Bibliography of geology and mineral resources of California for the year 1938, by Solon Shedd and LeVern W. Cutler.

Geology and mining of the borate deposits of the Kramer district, San Bernardino County, by Hoyt S. Gale.

Geology and mineral deposits of the Duncan Mills and Sebastopol quadrangles, by F. A. Johnson.

Geology of the Shasta copper district, by G. F. Seager.

Geology and ore deposits of the Bodie mining district, Mono County, by Francis Frederick.

Geology of the Amboy quadrangle, San Bernardino County, by John C. Hazzard.

Geology of San Nicolas and Santa Barbara Islands, by Luis E. Kemnitzer."

Ore Buyers Inspector's Summary

In August, 1938, three men employed on a drag-line dredge near Milton, California, were picked up by Sheriff Zwinge and John F. Bongard, Inspector, Division of Mines. One was charged with Grand Theft, to which he pleaded guilty, and sentenced to one year in the County Jail and three years probation. The other two pleaded guilty to Petty Theft charges and were fined $250.00 each. The total amount involved in this case was $4,100.00.

A new angle on the highgrading situation was opened up when the Milton Gold Dredge Company, owners of the dredge from which the gold was stolen instituted a civil action against the licensed gold buyers who had purchased the gold and the recovering of the amount of money equal to the value of the gold stolen.

On December 28, 1938, a decision was handed down by the Judge of the Superior Court of Tuolumne County awarding the Milton Gold Dredge Company, $4,100.00 damages, plus 7% interest from the date of each sale. This should be an effective weapon in curbing licensed gold buyers from purchasing stolen gold.

In August, 1938, six men working on a dredge near Redding, California, were arrested and pleaded guilty to Petty Theft in Justice Court, Ono, Shasta County, and were sentenced to sixty days in the county jail; during a period of two years these men had stolen $20,600.00. A suit against the gold buyers for the recovery of this amount has been filed by the owners of the Dredge. This was settled out of court for $5,000.00.

In September, 1938, our inspector was called to Los Angeles where investigation was made of a shipment of gold turned in by one of the licensed gold buyers of that city. The investigation disclosed that the gold had been stolen from a large mining concern in Alaska. Due to the fact that they did not wish to return the defendant to Alaska to stand trial, they did not prosecute, although the amount of gold was returned by the buyers to the Mining Company. They received a check for $1,400.74. The above case was closed.

An investigation was carried on by Federal Agent C. B. Rich and our Inspector Bongard regarding highgrading conditions in and around Amador County. The investigation reached its climax the early part of September, 1938, when eight persons were arrested for falsifying affidavits to the U. S. Mint and conspiracy to violate the Gold Reserve Act of 1934.

Investigation covered the years 1936, 1937 and 1938, and the records showed that the defendants had shipped to the U. S. Mint, San Francisco, an amount in excess of $800,000.00. These men were indicted by the U. S. Grand Jury in San Francisco, and convicted in Federal Courts, two receiving sentences of five years in the Federal Penitentiary, and two being acquitted.

There were several other persons picked up, but because the owners of the mines or dredges from which the gold was stolen did not wish to prosecute, the cases were dropped. Two other incidents of theft were detected, but lack of evidence forced us to drop the prosecution. In these cases the managers of the mines and dredges concerned were informed of the circumstances. A total of $7,600.00 was involved in these cases.

Numerous investigations were made by the Ore Buyers' Inspector in cases where owners of mining properties complained about not receiving their just royalties from leasers or operators. In all instances these were cleaned up. There were 195 Ore Buyers Licenses issued in 1938, and 72,000 Report Tickets were issued to the licensed gold buyers.

During the year 1939, the following resumé of activities is reported:

In January, three arrests were made, and charges of petty theft were placed against the culprits and terms served in the county jail for violation of the Ore Buyers' Act. In February, three arrests were made, involving some $16,000; two from a dredge—culprits not prosecuted because the management did not prefer charges. Four were arrested in March, which brought to a termination a large highgrading ring, all of whom received severe sentences. In April, three arrests were made and fines and jail sentences imposed. In June, two were convicted on eleven counts of falsifying affidavits to the U. S. Mint and on one count of conspiracy for violating the Gold Reserves Act, and sentence imposed of five years in the Federal Penitentiary. In June, an arrest was made of a millman and restoration of 108.23 oz. made to the mine owners; the individual received a jail term. In July, 48½ oz. were recovered from two Chinese, who were attempting to sell retort sponge. Also, arrests were made of another group of highgraders involving a large amount of gold, but the jury disagreed

and convictions were not made. In August, a highgrade ring, involving four individuals pleaded guilty to the charge of conspiracy to violate the Gold Reserves Act.

There were four arrests and convictions for grand theft; eight arrests and convictions for petty theft; twenty-three arrests on Federal charges, of which three were acquitted, and the jury disagreed on four; the other sixteen were convicted, sentenced and fined, and $10,860.00 in gold was confiscated by the Federal Government.

During 1939, there were 185 ore buyers' licenses issued; and some 77,000 report books distributed to the licensed gold buyers.

The activities of the Highgrade Branch during the year 1940, to date, consists of the following:

Four arrests were made in the Merced Falls District, three of whom were charged with petty theft and one charged with bribery; and another one in the Grass Valley District was apprehended and given a year's probation with the provision that restitution of $200.00 be made. Three more arrests and sentences to a jail term and fines were imposed.

During 1940 to date, there are 186 ore buyers' licenses issued, with some 60,000 tickets (Report of Production) distributed.

PUBLICATIONS

Publications issued July 1, 1938, to June 30, 1940:

July and October chapters (California Journal of Mines and Geology), of State Mineralogist's Report XXXIV. Among the more important subjects are:

- Mineral Resources of El Dorado County (with map).
- Strategic Minerals in California.
- Mineral High-Lights of California.
- Submarine Canyons Off the California Coast.
- Mineral Resources of Inyo County (with map).
- Geology and Ore Deposits of the Darwin Silver-Lead Mining District, Inyo County (with map).
- Sulphur Deposits of Inyo County.

Special articles on:

- The Mountain Copper Company, Ltd., Cyanide Treatment of Gossan.
- Use of Ultra-Violet Light in Prospecting for Scheelite.
- New State Lands Act of 1938.
- New Amendments to the 'Caminetti Act' (Congressional), 1938.
- Biennial Report of the State Mineralogist.

State Mineralogist's Report XXXV, 1939. Among the more important subjects included are:

- Mineral Resources of San Diego County (with map).
- Geology and Oil Possibilities of San Diego County.
- Mineral Resources of Shasta County (with map).
- Tertiary Formations of Northern Sacramento Valley (with map).
- Geology and Oil Possibilities of Caliente Range, Cuyama Valley and Carrizo Plain (with map).
- Bibliography of the Geology and Mineral Resources of California, for the year 1937.
- The Giant Goose Lake Meteorite from Modoc County.
- Quicksilver Resources of California (with map).

Special articles on:

The Prospect for 'Minor Metals' and Nonmetallic Minerals.
The Right to Mine.
The Public's Interest in Mine Taxation.
Costs of Trucking and Packing Ore in Western Gold-Mining Districts.
Strategic Minerals Act.
Assessment Work on Mining Claims for 1938-1939.
New Mining Legislation, 1939.
Sulphate Minerals at the Leviathan Sulphur Mine, Alpine County.

January and April, 1940, chapters (California Journal of Mines and Geology) of State Mineralogist's Report XXXVI. Among the more important subjects included are:

Current Mining Activity in Southern California.
Mineral Resources of Mono County (with map).
General Geology and Ores of the Blind Spring Hill Mining District, Mono County.

Special articles on:

Notes on Beryl with a Qualitative Analysis for Beryllium.
Strategic Minerals Investigation Followed by the U. S. Bureau of Mines.
Short Report on the Geological Formations Encountered in Driving the Mono Craters Tunnel.
Methods and Costs of Mining and Concentrating Chromite.

Bulletin 116. California Mineral Production and Directory of Mineral Producers for 1937, by Henry H. Symons, 202 pages, 6 illustrations. Gives detailed figures of commercial production of all mineral substances in California for the calendar year 1937.

Bulletin 117. California Mineral Production and Directory of Mineral Producers for 1938, by Henry H. Symons, 216 pages, 7 illustrations. Gives detailed figures of commercial production of all mineral substances in California for the calendar year 1938.

Conclusion:

In conclusion, we can but reiterate what we have said in previous reports: that California is outstanding in the diversity, economic value, and potentialities of her mineral resources. This is especially true and vital with reference to those minerals significant to national defense in the present world crisis. As the only state agency in California fostering the economic development of these resources, the Division of Mines deserves generous support for the continued maintenance of its services to the public and these industries, particularly in the allocation of funds for field work and the printing of reports and maps. The moneys spent on printing come back to the state treasury from the sales of the publications.

Respectfully submitted.

Walter W. Bradley,
State Mineralogist.

September 15, 1940.

STRATEGIC TAX EXEMPTION

In the excess-profits tax law, which took effect when signed by the President October 8th, there is an exemption from excess-profit taxes for corporations engaged in mining of certain strategic metals provided in the following significant paragraph: "In the case of any domestic corporation engaged in the mining of tungsten, quicksilver, manganese, platinum, antimony, chromite, or tin, the portion of the adjusted excess profits net income attributable to such mining in the United States shall be exempt from the tax imposed by this subchapter. The tax on the remaining portion of such adjusted excess profits net income shall be an amount which bears the same ratio to the tax computed without regard to this section as such remaining portion bears to the entire adjusted excess profits net income."

The selection of metals and minerals in this law was made to provide protection against new taxes for those firms thought likely to become engaged in special strategic mineral development soon. Three mineral commodities on the strategic list of the Army and Navy were not included, namely, nickel, mica, and quartz crystal. Platinum is the only one of the metals that was included which is on the critical-materials list, not on the strategic list.

FEDERAL LOANS FOR STRATEGIC MINERALS

AN ACT

To authorize the Reconstruction Finance Corporation to make loans for the development of deposits of strategic and critical minerals which in the opinion of the Corporation would be of value to the United States in time of war, and to authorize the Reconstruction Finance Corporation to make more adequate loans for mineral developmental purposes.

[PUBLIC—NO. 784—76TH CONGRESS] [CHAPTER 721—3D SESSION] [S. 4008]

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That section 14 of the Act entitled "An Act relating to direct loans for industrial purposes by Federal Reserve banks, and for other purposes," approved June 19, 1934, as amended, is amended to read as follows:

"SEC. 14. The Reconstruction Finance Corporation is authorized and empowered to make loans upon sufficient security to recognized and established corporations, individuals, and partnerships engaged in the business of mining, milling, or smelting ores. The Reconstruction Finance Corporation is authorized and empowered also to make loans to corporations, individuals, and partnerships engaged in the development of a quartz ledge, or vein, or other ore body, or placer deposit, containing gold, silver, or tin, or gold and silver, or any strategic or critical mineral which in the opinion of the Reconstruction Finance Corporation would be of value to the United States in time of war, when, in the opinion of the Reconstruction Finance Corporation, there is sufficient reason to believe that, through the use of such loan in the development of a lode, ledge, or vein, or mineral deposit, or placer gravel deposit, there will be developed a sufficient quantity of ore, or placer deposits of a sufficient value to pay a profit upon mining operations: *Provided,* That not to exceed $20,000 shall

be loaned to any corporation, individual, or partnership for such development purposes; except that not in excess of $40,000 in the aggregate may be loaned to any corporation, individual, or partnership for such purposes, if such corporation, individual, or partnership has expended funds previously obtained from the Reconstruction Finance Corporation for such purposes in such manner as to justify an additional loan for such purposes: *Provided further*, That there shall not be allocated or made available for such development loans a sum in excess of $10,000,000.''

Approved, September 16, 1940.

ADMINISTRATIVE

WALTER W. BRADLEY, State Mineralogist

Personnel

There are no changes in personnel of the Division to be recorded for the past three months.

New Publications

CALIFORNIA JOURNAL OF MINES AND GEOLOGY, April, 1940, being Chapter 2 of State Mineralogist's Report XXXVI. This chapter contains: "Mineral Resources of Mono County," accompanied by a map showing locations of mines; "General Geology and Ores of the Blind Spring Hill Mining District, Mono County"; and special articles on "Short Report on the Geological Formations Encountered in Driving the Mono Craters Tunnel"; "Methods and Costs of Mining and Concentrating Chromite." Also preliminary 1939 production data on the following mineral substances for which complete returns had come from the operators: Bentonite, Bituminous Rock, Borates, Cement, Gypsum, Lime, Limestone, Pumice and Volcanic Ash, Quicksilver, Salt Silica (Sand and Quartz), Slate, Soapstone and Talc, Soda, Tungsten. Also a list of new mineral specimen acquisitions in the Museum.

COMMERCIAL MINERAL NOTES (Nos. 208, 209, 210) August, September, October, respectively. These 'Notes' contain the lists of 'mineral deposits wanted' and 'mineral deposits for sale,' issued in the form of a mimeographed sheet monthly. It is mailed free to those on the mailing list for 'California Journal of Mines and Geology.' As an evidence of the interest in mines and mineral resources now showing considerable activity, this mimeographed 'sheet' has had to be expanded to five pages in recent months.

Mail and Files

The Division of Mines maintains, in addition to its correspondence files and the library, a mine file which includes original reports on the various mines and mineral properties of all kinds in California.

During each quarterly period there are several thousand letters received and answered at the San Francisco Office alone, covering almost every phase of prospecting, mining and developing mineral deposits, reduction problems, marketing of refined products and mining law. In addition to this, hundreds of oral questions are answered daily, both at the main office and the district offices, for the many inquirers who come in for personal interviews and to consult the files and library.

MINERALS AND STATISTICS

Statistics, Museum

HENRY H. SYMONS, Statistician and Curator

MUSEUM

The museum of the California State Division of Mines possesses an exceptionally fine collection of rocks and minerals of both economic and academic value. It ranks among the five foremost of such collections in North America and contains not only specimens of most of the known minerals found in California, but much valuable and interesting material from other states and foreign countries as well.

In the April 1935 number of 'California Journal of Mines and Geology' an index of the mineral museum of the Division was published. Since that time many changes and additions have been made in the collection, therefore, at this time it has been deemed advisable to print a revised index.

This collection has had some 21,000 specimens of rocks, minerals and ores donated to it, since it was established in 1880, having approximately 10,000 on exhibit at the present time, as there is insufficient exhibit space for all. Those not shown, however, are available for reference. There are over 1000 different species of minerals and varieties, many of these being extremely rare. The specimens are arranged in several groups.

The most important of the groups is the one of minerals placed according to the Dana "System of Mineralogy," which places all minerals in eight chemical classes, starting with the "Native Elements" (see index of exhibits). Under each of these sections are different subclasses, which are also based on chemical relationships, into which the mineral species is arranged so far as possible, usually including mineral groups having analogous chemical composition and similar crystallization. This group has 51 cases and contains the best samples of each species of mineral contained in the museum. It also contains numerous fine examples of crystallization, and endeavors to show as many forms of crystals as possible for each mineral.

Another group of importance is the county collections. This group occupies 39 cases and gives at least half a case for each county in California. These cases contain mainly minerals of commercial importance and ores of the various metals that are found within the boundaries of the county. Included in this group there are seven additional cases which have commercial minerals and ores from other states and foreign countries.

Fourteen cases are set aside for the ores of the various metals, in which the ores and ore minerals of each metal are grouped together, showing the type of ores from the most important locations throughout the world. There are 14 more cases devoted to commercial, industrial and saline minerals coming from numerous localities.

There is a rock collection in six large cases, each holding about 240 specimens showing practically all kinds of rocks, most of the varieties from several locations. Two of these cases are devoted to

rocks coming from the 'Mother Lode' in California, gathered by Harold W. Fairbanks in 1889, while obtaining data for ''Geology of the Mother Lode Region'' in Tenth Report of the State Mineralogist.

There are 16 tall cases, eight of which have miscellaneous specimens. Most of these specimens are too large for the regular museum cases. The remainder of these cases are devoted to building stones, numerous marbles, granites, sandstones and ornamental stones.

There are 3 cases in the museum in which many semiprecious gem stones are exhibited, both in the rough and cut and in the reading room there is a case devoted to California gem stones. A case contains some high-grade gold specimens. Two safes in the library are devoted chiefly to high-grade gold, some platinum and diamonds. Here is gathered one of the finest aggregates of crystallized gold or ''jewelry' rock made up of mostly California material, but having many excellent specimens from outside of the state. There are also samples of both placer gold and high-grade vein mineral. One shelf in the first safe is devoted to native platinum group metals, all of which originating in California. This safe also has several diamonds coming from Africa and California. A fluorescence case has recently been added to the museum. This case has a 50-inch NICO tube and a 30-inch cold quartz tube; we hope with these to display both fluorescence and phosphorescence in many minerals to the best advantage.

The reading room is just outside of the museum, the walls of which are made as an exhibit of California structural materials, brick, marble and granite, the floors being of tile, marble and magnesite. There is a sandstone railing with granite posts at the ends. The entrance from the reading room to the museum is decorated by an arch made of granite. The library entrance is made of pink and white sandstone on one side, and terra cotta on the other. There are four cases in the reading room, three of which have fossils and oil formation markers, and the other metals (smelter products) mainly reduced from Californian ores.

On display, on the walls of the museum, are also numerous pictures of mining, some dating as early as 1852 and giving a visible record of many historical mining operations. There is a model of a five-stamp mill, showing crusher, ore bin, feeder, five-stamp battery, amalgamation table, vanner type concentrating table, amalgamation barrel, etc., which is located in the rear of the museum. This mill was built by the Union Iron Works for the Paris Exposition and was exhibited at the St. Louis Fair in 1904, then it was donated to the State Bureau of Mines and was displayed at the Panama-Pacific International Exposition at San Francisco in 1915. A miniature, showing waterwheels and methods used by the Chinese miners in early days in California, now on display was loaned by Alta California, after the closing of the Golden Gate International Exposition in 1940.

This collection of minerals has been made up solely by donations and exchanges, as this department has no appropriation to purchase materials for exhibit. Mineral specimens suitable for exhibit purposes are solicited, and such gifts will be appreciated by the Division of Mines, as well as those who utilize the facilities of the division. Since the alphabetic index has been made, several friends of the department have supplied minerals not previously contained in the exhibit.

INDEX OF MINERAL COLLECTION IN THE MUSEUM

* In reading room.

† In library.

A

Case Numbers

H

I

J

LABORATORY

George L. Gary, Mineral Technologist

Since 1866 many lists have been published showing localities of California minerals. The last one, "Minerals of California," by Adolph Pabst, was published in 1938 by the Division of Mines as Bulletin 113.

It is the intention of the Division of Mines to publish in the quarterly new localities for minerals that are received by the laboratory for determination. So that this information may be accurate, it is requested that all specimens submitted for classification be accompanied by a letter giving the exact location where the material was found.

Corrections will also be noted as well as additions when called to our attention.

88. Correction: Bulletin No. 113, page 302, Sonoma County, scist should be schist.
89. **Hydrotroilite,** a hydrous iron sulfide and **forsterite,** a magnesium silicate has been found near the mouth of Cascade Canyon in the SW¼ of Sec. 31, T. 2 N., R. 7 W., S.B.M., San Bernardino County and in the "New City Quarry" near Victoria Avenue, Riverside, Riverside County.
90. **Malacolite,** a calcium-magnesium pyroxene and **forsterite,** a magnesium silicate has been found on the northwest slope of Ontario Peak, in the eastern San Gabriel Mountains, San Bernardino County.
91. **Atacamite,** a hydrous copper oxychloride was reported from Avenal Creek, T. 23 S., R. 16 E., Kings County.
92. Correction, Bulletin No. 113, page 271. The formula for spodumene should be $LiAl\ (SiO_3)_2$.
93. Correction, Bulletin No. 113, page 152. The formula for malachite should be $CuCO_3.Cu(OH)_2$.
94. Correction, Bulletin No. 113, page 340. Chondroite, should be chondrodite.
95. Correction, Bulletin No. 113, page 33. Osmiridum should be Osmiridium.

LIBRARY

John C. O'Brien, Librarian

In addition to the numerous standard works, authoritative information on many phases of the mining and mineral industry is constantly being issued in the form of reports and bulletins by various government agencies.

The library of the Division of Mines contains over six thousand selected volumes on mines, mining and allied subjects, and it is also a repository for reports and bulletins of the technical departments of federal and state governments and of educational institutions, both domestic and foreign.

It is not the dearth of the latter publications, but rather a lack of knowledge of just what has been published and where the reports may be consulted or obtained, that embarrasses the ordinary person seeking specific information.

To assist in making the public acquainted with this valuable source of current technical information, California Journal of Mines and Geology contains under this heading a list of all books and official reports and bulletins received which pertain particularly to mining in California.

Files of all the leading technical journals will be found in the library, and county and state maps, topographical sheets and geological folios. Current copies of local newspapers published in the mining centers of the state are available for reference.

The library and reading room are open to the public during the usual office hours, when the librarian may be freely called upon for all necessary assistance.

OFFICIAL PUBLICATIONS RECEIVED WHICH HAVE SPECIAL INTEREST OR REFERENCE TO CALIFORNIA

Governmental, National:

U. S. Geological Survey:

Maps:

Camp Rincon Quadrangle, Los Angeles County.
Pico Quadrangle, Los Angeles County.

U. S. Bureau of Mines:

Report of Investigations:

3533 Active List of Permissible Explosives and Blasting Devices Approved Prior to June 30, 1940.
3535 A Method for Determining the Water Content of Oil Sands.
3540 Measurements of Compressibility of Consolidated Oil-Bearing Sands.

Information Circulars:

7133 Effect of Hydrogen—In Concentration on the Growth of Hydrogen and Carbon Monoxide Bacteria.
7134 Production, Employment and Output per Mo. in Gypsum Mining.

Books:

Dictionary of Geological Terms, by C. M. Rice.
East is East and West is West, by Carlos Emmons Cummings, M.D. (Bull. of the Buffalo Society of Natural Sciences, Vol. XX—1940.)
Kemps Handbook of Rocks, Sixth Edition, 1940, Grout.
The Mineral Industry During 1939, Vol. 48.
Petroleum World, Annual Review, 1940.

PUBLICATIONS RECEIVED CURRENTLY AND FORMER REPORTS AVAILABLE FOR REFERENCE

Governmental, State.

Alabama Geological Survey, University.
Arizona Bureau of Mines, Tucson.
Arkansas Geological Survey, Little Rock.
Colorado Bureau of Mines, Denver.
Connecticut Geological and Natural History Survey, Hartford.
Florida Department of Conservation, Tallahassee.
Georgia Division of Geology, Atlanta.
Idaho Bureau of Mines and Geology, Moscow.
Illinois Geological Survey, Urbana.
Iowa Geological Survey, Des Moines.
State Geological Survey of Kansas, Lawrence.
Kentucky Geological Survey, Frankfort.
Louisiana Department of Conservation, New Orleans.
Maine State Geologist, Augusta.
Maryland Geological Survey, Baltimore.
Michigan Geological Survey, Lansing.
Minnesota Geological Survey, Minneapolis.
Mississippi State Geological Survey, University.
Missouri Bureau of Geology & Mines, Rolla.
Montana Bureau of Mines and Geology, Butte.
Nebraska Geological Survey, Lincoln.
Nevada State Bureau of Mines, Reno.
New Jersey Department of Conservation and Development, Trenton.
New Mexico Bureau of Mines and Mineral Resources, Socorro.
North Carolina Geological & Economic Survey, Chapel Hill.
North Dakota Geological Survey, Grand Forks.
Ohio Geological Survey, Columbus.
Oklahoma Geological Survey, Norman.
Oregon State Department of Geology and Mineral Industries, Portland.
Pennsylvania Topographic and Geological Survey, Harrisburg.
South Dakota State Geological Survey, Vermillion.
Tennessee Division of Geology, Nashville.
Texas Bureau of Economic Geology, Austin.
Virginia Geological Survey, University.
Washington State Department of Conservation and Development, Pullman.
West Virginia Geological Survey, Morgantown.
Wisconsin Geological & Natural History Survey, Madison.
Wyoming Geological Survey, Cheyenne.

Governmental, Foreign.

Alberta Research Council, Edmonton.
Argentina Direccion General de Minas y Geologica, Buenos Aires.
British Columbia Minister of Mines, Victoria.
British Museum and Natural History, London.
Canada Department of Mines, Ottawa.
Cuerpo de Ingenieros de Minas y Aguas del Peru, Lima.
Geological Service of Minas Geraes, Bella Horizonte, Brazil.
Geological Survey of Scotland.
Instituto Historica e Geographico Rio de Janeiro.
Museo de Historia Natural de Montevideo, Uruguay.
New South Wales Department of Mines, Sydney, Australia.
New Zealand Geological Survey Branch, Wellington.
Nova Scotia Department of Public Works and Mines, Halifax.

Ontario Department of Mines, Toronto, Canada.
Quebec Bureau of Mines, Quebec.
Queensland Department of Mines, Brisbane, Australia.
South Australia Department of Mines, Adelaide.
Transvaal Chamber of Mines, Johannesburg, South Africa.
Western Australia, Geological Survey, Perth.

Societies and Educational Institutions.

Academia de Ciencias y Artes de Barcelona, Spain.
Academy of Natural Sciences, of Philadelphia.
American Association of Petroleum Geologists, Tulsa, Oklahoma.
American Geographical Society of New York.
American Institute of Mining and Metallurgical Engineers, New York.
American Journal of Science, New Haven, Conn.
American Philosophical Society, Philadelphia.
Australian Museum, Sydney.
California Academy of Sciences, San Francisco.
Carnegie Institution of Washington.
Cleveland Museum of Natural History, Cleveland, Ohio.
Colorado College Publications, Colorado Springs.
Colorado Scientific Society, Denver.
Commonwealth Club, San Francisco.
Economic Geology, Lancaster, Pa.
Field Museum of Natural History, Chicago.
Franklin Institute of the State of Pennsylvania, Lancaster, Pa.
Geological Society of America, Columbia University, New York.
Geographical Society of London.
Institution of Mining and Metallurgy, London.
Instituto Geologico de Mexico, Mexico, D. F.
Journal of Geology, Chicago.
Mineralogical Society of America, Menasha, Wisconsin.
Michigan College of Mining and Technology, Houghton.
Mining and Metallurgical Society of America, New York.
Museu Nacional, Rio de Janeiro.
National Research Council, Washington, D. C.
New York Academy of Sciences, New York.
New York State Museum, Albany.
Pennsylvania State College, State College.
Philippine Journal of Science, Manila.
Royal Society of South Australia, Adelaide.
Seismological Society of America, Stanford University.
Sierra Club, San Francisco.
Society of Economical Paleontologists and Mineralogists, Fort Worth, Texas.
Southern California Acadamy of Sciences, Los Angeles.
University of California Publications in Engineering, Berkeley.
University of California Publications in Geography, Berkeley.
University of California Publications in Geology, Berkeley.
University of Harvard, Department of Mineralogy and Petrography, Cambridge, Mass.

Current Magazines on File.

For the convenience of persons wishing to consult the technical magazines in the reading room, a list of those on file is appended:

Asbestos, Philadelphia, Pennsylvania.
Brick and Clay Record, Chicago.
California Journal of Development, San Francisco.
California Mining Journal, Auburn.
California Oil World, Los Angeles.
California Safety News, San Francisco.
Canadian Mining Journal, Gardenvale, Quebec.
Chemical and Metallurgical Engineering, New York City.
Chemical Engineering and Mining Review, Melbourne, Australia.
Civil Engineering, New York City.

Colorado School of Mines, Golden, Colorado.
Conservationist, Sacramento, California.
Engineering and Mining Journal, New York City.
Fuel Oil, Chicago, Illinois.
Fusion Facts, Whittier, California.
Gold, Toronto, Canada.
Grizzly Bear, Los Angeles.
Hercules Mixer, Wilmington, Delaware.
Independent Monthly, Tulsa, Oklahoma.
Lubrication, The Texas Co., New York City.
Metals and Alloys, Pittsburgh, Pennsylvania.
Mine and Mill World Digest, San Francisco.
Mining and Contracting Review, Salt Lake City.
Mineralogist, Portland, Oregon.
Mining Congress Journal, Washington, D. C.
Mining and Industrial News, San Francisco.
Mining and Geological Journal, Melbourne, Victoria, Australia.
Mining Journal, London.
Mining Journal, Phoenix, Arizona.
Mining and Metallurgy, New York City.
Mining Review, Salt Lake City.
Mining World, Seattle.
Nevada Mining Bulletin, Las Vegas, Nevada.
Nickel Steel Topics, New York City.
Northwest Mining, Spokane, Washington.
Northwest Science, Cheney, Washington.
Oil and Gas Journal, Tulsa, Oklahoma.
Oil, Paint and Drug Reporter, New York City.
Oil Weekly, Houston, Texas.
Pacific Purchaser, San Francisco.
Pacific Chemical and Metallurgical Industries, San Francisco.
Petroleum World, Los Angeles.
Queensland Government Mining Journal, Brisbane, Australia.
Rock Products, Chicago.
Rocks and Minerals, Peekskill, New York.
Scientific American, New York City.
Southwest Builder and Contractor, Los Angeles.
Stabilizer, Los Angeles.
Standard Oil Bulletin, San Francisco.
Stone, New York City.
Western Mining News, San Francisco.

Newspapers.

The following papers are received and kept on file in the library:

Alaska Weekly, Seattle, Washington.
Amador Dispatch, Jackson, California.
Banner, Sonora, California.
Barstow Printer, Barstow, California.
Bridgeport Chronicle-Union, Bridgeport, California.
Calaveras Californian, Angels Camp, California.
Calaveras Prospect, San Andreas, California.
Colusa Sun-Herald, Colusa, California.
Courier Free Press, Redding, California.
Daily Commercial News, San Francisco, California.
Del Norte Triplicate, Crescent City, California.
Denver Mining Record, Denver, Colorado.
Georgetown Gazette, Georgetown, California.
Humboldt Beacon, Humboldt.
Inyo Independent, Independence, California.
Inyo Register, Bishop, California.
Las Vegas Age, Las Vegas, Nevada.
Livermore Herald, Livermore, California.
Los Angeles Times, Los Angeles, California.

Mariposa Gazette, Mariposa, California.
Mercury Register, Oroville, California.
Mining Press, Reno, Nevada.
Mohave Miner, Kingman, Arizona.
Mojave-Randsburg Record, Mojave, California.
Morning Union, Grass Valley, California.
Mountain Messenger, Downieville, California.
Needles Nugget, Needles, California.
Nevada Mining Bulletin, Las Vegas, Nevada.
Oil Marketer, Bayonne, New Jersey.
Owens Valley Progress-Citizen, Lone Pine, California.
Placer Herald, Auburn, California.
Plumas Independent, Quincy, California.
Randsburg Times, Randsburg, California.
San Diego News, San Diego, California.
Shasta Courier, Redding, California.
Siskiyou News, Yreka, California.
Stockton Record, Stockton, California.
Tehachapi News, Tehachapi, California.
Terra Bella News, Terra Bella, California.
Tuolumne Independent, Sonora, California.
Tuolumne Prospector, Tuolumne, California.
Union Democrat, Sonora, California.
Ventura County News, Ventura, California.
Waterford News, Waterford, California.
Weekly Trinity Journal, Weaverville, California.
Western Mineral Survey, Salt Lake City, Utah.
Western Sentinel, Etna Mills, California.

PRODUCERS AND CONSUMERS

The producer and consumer of mineral products are mutually dependent upon each other for their prosperity, and one of the most direct aids rendered by this Division to the mining industry in the past has been that of bringing producers and consumers into direct touch with each other.

This work has been carried on largely by correspondence, supplemented by personal consultation. Lists of buyers of all the commercial minerals produced in California have been made available to producers upon request, and likewise the owners of undeveloped deposits of various minerals, and producers of them, have been made known to those looking for raw mineral products.

When the publication of *Mining in California* was on a monthly basis, current inquiries from buyers and sellers were summarized and lists of mineral products or deposits 'wanted' or 'for sale' included in each issue.

It is important that inquiries of this nature reach the mining public as soon as possible and in order to avoid the delay incident to the present quarterly publication of CALIFORNIA JOURNAL OF MINES AND GEOLOGY, these lists are now issued monthly in the form of a mimeographed sheet under the title of 'Commercial Mineral Notes,' and sent to those on the mailing list of CALIFORNIA JOURNAL OF MINES AND GEOLOGY.

EMPLOYMENT SERVICE

Following the establishment of the Mining Division branch offices in 1919, a free technical employment service was offered as a mutual aid to mine operators and technical men for the general benefit of the mineral industry.

Briefly summarized, men desiring positions are registered, the cards containing an outline of the applicant's qualifications, position wanted, salary desired, etc., and as notices of 'positions open' are received, the names and addresses of all applicants deemed qualified are sent to the prospective employer for direct negotiations.

Telephone and telegraphic communications are also given immediate attention.

Technical men, or those qualified for supervisory positions, and vacancies of like nature only, are registered, as no attempt will be made to supply common mine and mill labor.

Registration cards for the use of both prospective employers and employees may be obtained upon request, and a cordial invitation is extended to the industry to make free use of the facilities afforded. Parties interested should communicate direct with our San Francisco office.

PUBLICATIONS OF THE DIVISION OF MINES

During the past fifty-six years, in carrying out the provisions of the organic act creating the former California State Mining Bureau, there have been published many reports, bulletins and maps which go to make up a library of detailed information on the mineral industry of the State, a large part of which could not be duplicated from any other source.

One feature that has added to the popularity of the publications is that many of them have been distributed without cost to the public, and even the more elaborate ones have been sold at a price which barely covers the cost of printing.

Owing to the fact that funds for the advancing of the work of this department have usually been limited, the reports and bulletins mentioned are printed in limited editions many of which are now entirely exhausted.

Copies of such publications are available for reference, however, in the offices of the Division of Mines, in the Ferry Building, San Francisco; State Building, Los Angeles; State Office Building, Sacramento; Redding; and Division of Oil and Gas at Santa Barbara, Santa Paula, Taft, Bakersfield, Coalinga. They may also be found in many public, private and technical libraries in California and other states and foreign countries.

A catalog of all publications from 1880 to 1917, giving a synopsis of their contents, is issued as Bulletin No. 77.

Publications in stock may be obtained postpaid by addressing the San Francisco, Los Angeles or Sacramento offices and enclosing the requisite amount.

Remittances of stamps in an amount not to exceed 26 cents, currency or coin will be accepted at sender's risk. Payment is preferred in the form of money orders.

Money orders should be made payable to the Division of Mines.

NOTE.—The Division of Mines frequently receives requests for some of the early Reports and Bulletins now out of print, and it will be appreciated if parties having such publications and wishing to dispose of them will advise this office.

Write for latest revised price list.

REPORTS

Asterisks (**) indicate the publication is out of print. — Price (including postage and sales tax)

**First Annual Report of the State Mineralogist, 1880, 43 pp. Henry G. Hanks ---- ----

**Second Annual Report of the State Mineralogist, 1882, 514 pp., 4 illustrations, 1 map. Henry G. Hanks ---- ----

**Third Annual Report of the State Mineralogist, 1883, 111 pp., 21 illustrations. Henry G. Hanks ---- ----

**Fourth Annual Report of the State Mineralogist, 1884, 410 pp., 7 illustrations. Henry G. Hanks ---- ----

**Fifth Annual Report of the State Mineralogist, 1885, 234 pp., 15 illustrations, 1 geological map. Henry G. Hanks ---- ----

Sixth Annual Report of the State Mineralogist, Part I, 1886, 145 pp., 3 illustrations, 1 map. Henry G. Hanks -- Price $0.75, sales tax $0.02 $0.77

Part II, 1887, 222 pp., 36 illustrations. William Irelan, Jr. ---- Price $0.75, sales tax $0.02 .77

**Seventh Annual Report of the State Mineralogist, 1887, 315 pp. William Irelan, Jr. ---- ----

**Eighth Annual Report of the State Mineralogist, 1888, 948 pp., 122 illustrations. William Irelan, Jr. ---- ----

**Ninth Annual Report of the State Mineralogist, 1889, 352 pp., 57 illustrations, 2 maps. William Irelan, Jr. ---- ----

**Tenth Annual Report of the State Mineralogist, 1890, 983 pp., 179 illustrations, 10 maps. William Irelan, Jr. ---- ----

Eleventh Report (First Biennial) of the State Mineralogist, for the two years ending September 15, 1892, 612 pp., 73 illustrations, 4 maps. William Irelan, Jr. ---- Price $1.50, sales tax $0.05 1.55

**Twelfth Report (Second Biennial) of the State Mineralogist, for the two years ending September 15, 1894, 541 pp., 101 illustrations, 5 maps. J. J. Crawford ---- ----

**Thirteenth Report (Third Biennial) of the State Mineralogist, for the two years ending September 15, 1896, 726 pp., 93 illustrations, 1 map. J. J. Crawford ---- ----

Chapters of the State Mineralogist's Report, XIV Biennial Period, 1913-1914, Fletcher Hamilton:

**Mines and Mineral Resources, Amador, Calaveras and Tuolumne Counties, 172 pp., paper ---- ----

Mines and Mineral Resources, Colusa, Glenn, Lake, Marin, Napa, Solano, Sonoma and Yolo Counties, 208 pp., paper ---- Price $0.75, sales tax $0.02 .77

**Mines and Mineral Resources, Del Norte, Humboldt and Mendocino Counties, 59 pp., paper ---- ----

**Mines and Mineral Resources, Fresno, Kern, Kings, Madera, Mariposa, Merced, San Joaquin and Stanislaus Counties, 220 pp., paper ---- ----

**Mines and Mineral Resources of Imperial and San Diego Counties, 113 pp., paper ---- ----

**Mines and Mineral Resources, Shasta, Siskiyou and Trinity Counties, 180 pp., paper ---- ----

**Fourteenth Report of the State Mineralogist, for the Biennial Period 1913-1914, Fletcher Hamilton, 1915:

A General Report on the Mines and Mineral Resources of Amador, Calaveras, Tuolumne, Colusa, Glenn, Lake, Marin, Napa, Solano, Sonoma, Yolo, Del Norte, Humboldt, Mendocino, Fresno, Kern, Kings, Madera, Mariposa, Merced, San Joaquin, Stanislaus, San Diego, Imperial, Shasta, Siskiyou and Trinity Counties, 974 pp., 275 illustrations, cloth ---- ----

Chapters of the State Mineralogist's Report, XV Biennial Period, 1915-1916, Fletcher Hamilton:

**Mines and Mineral Resources, Alpine, Inyo and Mono Counties, 176 pp., paper ---- ----

Mines and Mineral Resources, Butte, Lassen, Modoc, Sutter and Tehama Counties, 91 pp., paper ---- Price $0.75, sales tax $0.02 .77

REPORTS—Continued

Asterisks (**) indicate the publication is out of print. — Price (including postage and sales tax)

Mines and Mineral Resources, El Dorado, Placer, Sacramento and Yuba Counties, 198 pp., paper ---- Price $0.75, sales tax $0.02	$0.77
Mines and Mineral Resources, Monterey, San Benito, San Luis Obispo, Santa Barbara and Ventura Counties, 183 pp., paper ---- Price $0.75, sales tax $0.02	.77
**Mines and Mineral Resources, Los Angeles, Orange and Riverside Counties, 136 pp., paper	----
**Mines and Mineral Resources, San Bernardino and Tulare Counties, 186 pp., paper	----
**Fifteenth Report of the State Mineralogist, for the Biennial Period 1915-1916, Fletcher Hamilton, 1917: A General Report on the Mines and Mineral Resources of Alpine, Inyo, Mono, Butte, Lassen, Modoc, Sutter, Tehama, Placer, Sacramento, Yuba, Los Angeles, Orange, Riverside, San Benito, San Luis Obispo, Santa Barbara, Ventura, San Bernardino and Tulare Counties, 990 pp., 413 illustrations, cloth	----
Chapters of the State Mineralogist's Report XVI, Biennial Period, 1917-1918, Fletcher Hamilton:	
Mines and Mineral Resources of Nevada County, 270 pp., paper ---- Price $1.00, sales tax $0.03	1.03
Mines and Mineral Resources of Plumas County, 188 pp., paper ---- Price $0.75, sales tax $0.02	.77
Mines and Mineral Resources of Sierra County, 144 pp., paper ---- Price $0.75, sales tax $0.02	.77
Seventeenth Report of the State Mineralogist, 1920, 'Mining in California during 1920,' Fletcher Hamilton; 562 pp., 71 illustrations, cloth ---- Price $2.50, sales tax $0.08	2.58
Eighteenth Report of the State Mineralogist, 1922, 'Mining in California,' Fletcher Hamilton. Chapters published monthly beginning with January, 1922:	
**January, **February, **March, **April, May, June, July, August, September, October, November, December, 1922 ---- Price $0.40, sales tax $0.01	.41
Chapters of Nineteenth Report of the State Mineralogist, 'Mining in California,' Fletcher Hamilton and Lloyd L. Root. January, February, March, September, 1923 ---- Price $0.40, sales tax $0.01	.41
Chapters of Twentieth Report of the State Mineralogist, 'Mining in California,' Lloyd L. Root. Published quarterly. January, April, July, October, 1924, per copy ---- Price $0.40, sales tax $0.01	.41
Chapters of Twenty-first Report of the State Mineralogist, 'Mining in California,' Lloyd L. Root. Published quarterly:	
January, 1925, Mines and Mineral Resources of Sacramento, Monterey and Orange Counties ---- Price $0.40, sales tax $0.01	.41
April, 1925, Mines and Mineral Resources of Calaveras, Merced, San Joaquin, Stanislaus and Ventura Counties ---- Price $0.40, sales tax $0.01	.41
**July, 1925, Mines and Mineral Resources of Del Norte, Humboldt and San Diego Counties	----
**October, 1925, Mines and Mineral Resources of Siskiyou, San Luis Obispo and Santa Barbara Counties	----
Chapters of Twenty-second Report of the State Mineralogist, 'Mining in California,' Lloyd L. Root. Published quarterly:	
**January, 1926, Mines and Mineral Resources of Trinity and Santa Cruz Counties	----
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